UNIVERSITY OF LONDON THESIS

Degree Ph.D. Year 2008 Name of Author SIMAO, A.

A learning-enhancing, web-based public participation system for spatial planning:

an application to the wind farm siting problem

by

Ana Cristina Rocha Simão

Centre for Advanced Spatial Analysis & Department of Geography

University College London

University of London

A thesis submitted for the degree of Doctorate of Philosophy

July 2008

I, Ana Simão, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

Public participation in government is a hallmark of a democratic society. In the planning realm, public participation has come to define good planning and is seen as fundamental to achieving lasting and possible solutions. The effectiveness of public participation, however, is directly related to the volume and quality of available information and the support that citizens have in making sense of this information, both to develop positions and to make informed contributions. This thesis develops a learning-enhancing framework for public participation in spatial planning.

Departing from the analysis of a classic theory of learning, Personal Construct Theory by George Kelly (1955), an innovative design for a spatial public participation system is proposed. This system integrates three elements: an information exploration element; a Multi-criteria Spatial Decision Support System (MC-SDSS); and an Argumentation Map (AM). In concert, these elements make information available and address the two components of learning suggested by Kelly: the individual component (making sense of one's own experiences of the real world) and the social component (social interaction).

A web-based system is developed and used to assess the adequacy of the proposed conceptual framework. The prototype system is applied to the pertinent and controversial spatial problem of onshore wind farm siting using a study area in the county of Norfolk, England. The prototype, called WePWEP (Web-based Participatory Wind Energy Planning), is tested in a quasi-naturalistic experiment. Test results evaluate the proposed framework favourably and highlight some aspects of the prototype that can be improved.

Table of Contents

List of Tables

List of Figures

Glossary of Acronyms

ADF	Application Development Framework
AHP	Analytical Hierarchy Process
AIS	Autonomous Intelligent Systems
AONB	Area of Outstanding Natural Beauty
API	Application Programming Interface
AM	Argumentation Map
AS	Argumentation Systems
BHS	The British Horse Society
BWEA	British Wind Energy Association
CA	The Countryside Agency
CASA	Centre for Advanced Spatial Analysis
CHEST	Combined Higher Education Software Team
CO_2	Carbon Dioxide
CRANES	Coordinator for Rational Arguments through Nested Substantiation
CSCW	Computer-Supported Collaborative Work
CSDM	Collaborative Spatial Decision Making
DBMS	Database Management System
DEFRA	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model

DETR	Department of the Environment, Transport and the Regions
DLUA	Developed Land Use Areas
DM	Decision maker
DTI	Department of Trade and Industry
DTM	Digital Terrain Model
DSM	Digital Surface Model
DSS	Decision Support Systems
DWEA	Danish Wind Industry Association
EAST2	Enhanced Adaptive Structuring Theory, version 2
EC	European Commission
EEC	European Economic Community
EIA	Environment Impact Assessment
ELECTRE	Elimination et Choice Translating Reality
EH	English Heritage
EN	English Nature
ESRI	Environmental Systems Research Institute
EU	European Union
EWEA	European Wind Energy Association
FoE	Friends of Earth
GeoDF	GIS-enabled Online Discussion Forum
GIS	Geographical Information System
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IAP2	International Association for Public Participation
IBIS	Issue-based Information System
ICT	Information and Communication Technologies
IDE	Integrated Development Environment
Java VM	Java Virtual Machine

JSF	JavaServer Faces
JSP	JavaServer Pages
LI/IEMA	Landscape Institute and Institute of Environmental Management and Assessment
LNR	Local Nature Reserves
LPA	Local Planning Authority
LUC	Land Use Consultants
MADM	Multi-attribute Decision Making
MCDM	Multi-criteria Decision Making
MC	Multi-criteria
MG-GIS	Multi-criteria – Geographical Information System
MC-SDSS	Multi-criteria Spatial Decision Support System
MoD	Ministry of Defence
MSc	Master in Science
NCC	Norfolk County Council
NCGIA	National Center for Geographic Information and Analysis
NIABY	Not In Anyone's Backyard
NIMBY	Not In My Back Yard
OA	Output Area
ODPM	Office for the Deputy Prime Minister
OGC	Open Geospatial Consortium, Inc.
ONS	Office for National Statistics
OS	Ordnance Survey
OSDM	Open Spatial Decision Making
PCT	Personal Construct Theory
PGIST	Participatory Geographic Information Systems for Transportation
PhD	Doctor of Philosophy
PPGIS	Public Participation Geographical Information Systems
PPS	Planning Policy Statement

RAF	Royal Air Force
RO	Renewable Obligation
RPG	Regional Planning Guidance
RSPB	The Royal Society for the Protection of Birds
RSS	Regional Spatial Strategy
SAW	Simple Additive Weighting
SDK	Software Development Kit
SDSS	Spatial Decision Support System
SNH	Scottish Nature Heritage
SUDSS	Spatial Understanding and Decision Support System
TAN	Technical Advice Note
TCI/IP	Transmission Control Protocol/Internet Protocol
TLB	Toulmin-based logic
TOC	Table of Contents
TOPSIS	Technique for Order Preference by Similarity to the Ideal Solution
UCL	University College London
UEA	University of East Anglia
UK	United Kingdom
UML	Unified Modelling Language
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nation Environment Programme
URL	Uniform Resource Locator
USA	United States of America
VIA	Visual Impact Assessment
VBA	Visual Basic for Applications
VM	Virtual Machine
WePWEP	Web-based Participatory Wind Energy Planning

WMC	Web Map Contexts
WMS	Web Mapping Services
WWEA	World Wind Energy Association
WWF-UK	World Wildlife Federation-United Kingdom
XML	Extensible Markup Language
ZVI	Zone of Visual Influence

Acknowledgements

It is absolutely impossible to mention explicitly everyone who contributed, either directly or indirectly, to this work and made it possible. Even so, I would like to acknowledge the following persons.

First of all, I would like to express my gratitude to my supervisors Dr. Paul Densham and Dr. Muki Haklay; Dr. Paul Densham for the fruitful discussions and encouragement while the research slowly developed; Dr. Muki Haklay for providing advice at critical stages, the necessary computational resources for the research (through the Department of Geomatic Engineering) and feedback on my drafts so promptly.

I also want to express my deepest thanks to all people at the Centre for Advanced Spatial Analysis (CASA), including my peers, the directors Mike Batty and Paul Longley and the support staff. Their companionship and expertise made CASA a stimulating and enjoyable working environment. Special thanks are due to Aidan Slingsby and Daryl Lloyd for their constant support throughout this journey and much-needed assistance, particularly during the setting up of the computational and programming platform for this research. I am also grateful to the Department of Geomatic Engineering for giving me desk space. There, José Paulo Almeida, Claire Ellul and Sampson Ayugi were very supportive and great friends.

My thanks also go for all my colleagues from the Department of Civil Engineering, University of Coimbra, Portugal, in particular from the Laboratory of Urbanism, Transports and Roads, for their encouragement to carry on, since the very beginning, but especially during the last stage of this work. A special reference is due to Dr. João Coutinho-Rodrigues for his interest in this research and useful comments of my final draft; also for his support before the Institution University of Coimbra.

I also owe a word of thanks to all of those who have contributed to this research (which I do not name for it would be a long list), either by making available the necessary data, taking part in the tests and experiments carried out or simply providing feedback on the developed prototype.

Acknowledgements are due to two institutions: Fundação para a Ciência e a Tecnologia who sponsored this PhD under scholarship ref. SFRH/BD/11092/2002 and Faculdade de Ciências e Tecnologia, Universidade de Coimbra, who, through a study leave, provided me the conditions to study in such a fantastic research centre as CASA is. Without their support this research would not have been possible.

Last but not least, I want to express my profound recognition to Nelson, my fiancée, for the numerous hours that he had to entertain himself when I was "just about to finish" a line of code or a paragraph and the spiritual revitalisation whenever I was fed-up and everything was going wrong; also to my parents for their unconditional enthusiasm and encouragement during the completion of this research – many times on the other side of a telephone line; and, naturally, my friends for having much contributed for my well-being.

Despite the great experience that doing a PhD at CASA has been ... ooh, I am so grateful that it is over now!

Thank you all so much!

Ana Simao, July 2008

Chapter I

Introduction

I.1. Overview

Public participation in spatial and environmental planning is the order of the day. To overcome drawbacks associated with traditional methods of participation, web-based public participation systems have been proposed. In particular, two types of systems have been developed, addressing distinct facets of the planning process: spatial decision support systems (SDSSs) support rationality in and accountability of the process while argumentation maps (AMs) support collaboration and inclusiveness in the process.

This thesis focuses on one aspect of web-based public participation systems that has been largely overlooked in the literature: the crucial role that these systems play in promoting informed contributions by those citizens willing to participate in the planning process.

George Kelly (1955) in his personal construct theory (PCT) postulates that individuals learn (acquire experience as he poses it) by making sense of their own experiences of the real world and by interacting with other individuals. Two components of learning can, thus, be identified: an individual component and a social one.

In the light of PCT, this thesis claims that SDSSs and AMs are complementary systems from the perspective of inducing learning: while the former facilitates the exploration of individual tacit knowledge, preferences and assumptions in relation to the decision problem, hence, tackling Kelly's individual component of learning; the latter addresses the social component of learning by exposing reasoning and argumentation discourses, which triggers critical thought and encourages exchange of ideas.

Based on this complementarity, the thesis proposes the integration of these two types of systems. The hypothesis is that, besides tackling the two components of learning, synergies arising from the integration of the two types of systems will yield a learning-enhancing framework that fosters public participation in spatial planning.

To investigate to what extent the resulting framework does indeed foster and enhance learning, this is developed into a proof-of-concept public participation system and implemented as a web-based prototype that uses the strategic planning of wind farm sites as a case study. The prototype is subsequently tested and conclusions are drawn with respect to how participants used the prototype during testing and their feedback on it, particularly regarding its design motivation: fostering and enhancing learning.

Although motivated by an interest in public participation in spatial and environmental planning, the core contribution of this thesis is on the integration of an SDSS and an AM at theoretical and implementation levels; consequently, this thesis is better framed in the research streams of systems design and systems development.

I.2. The need for learning-enhancing public participation systems

Typically, stakeholders (and generically the wider public) interested in participating in a spatial or environmental decision-making process hold partial (and sometimes flawed) knowledge on the issues involved. For instance, not all citizens willing to contribute to the wind farm siting problem know about the extensive set of aspects that needs consideration, ranging from the required separation distance between trees and wind turbines to avoid turbulent wind flow to the minimum wind speed required to ensure an economically viable investment. In addition, misconceptions are present – a frequent one, for example, is that wind turbines are noisy. In fact, modern wind turbines are remarkably quiet as they have been specifically designed to keep noise to a minimum.

Furthermore, people are often not fully aware of their "known" preferences with regard to decision-making. Several studies (e.g. Densham, 1990) have shown that, when confronted with the consequences of stated preferences, individuals often realise they need to refine them.

Together, these two aspects highlight the need for a system that fosters and enhances learning in the context of public participation. They also provide a reason to subscribe to Hamilton, Trodd, Zhang, Fernando and Watson's (2001) stance that participating in spatial planning requires/

involves participating in a learning process - it is this learning process that enables participants to develop informed contributions to the decision-making process.

This need/stance constitutes the basis for this research and justifies its ultimate goal: to develop a learning-enhancing, web-based public participation system for spatial planning.

Once available, such a system would fulfil the democratic ideals behind public participation in decision-making – a web-based can potentially be available to every citizen. Furthermore, such a system could also endorse, and even reinforce, the vision of public participation as an aim in itself, inasmuch as it makes individuals more intelligent and aware of their surrounding environment: the *educational enlightenment* argument articulated by Mitcham (1997) in justifying public involvement in technical decision-making.

More pragmatically, benefits from using the system are anticipated to accrue to both the participants in the planning process (henceforth referred to as participants) and the decision-maker(s). By being given the opportunity to extend their knowledge, and thus evolve during the very process of participation, participants are expected to feel better rewarded for their time and engagement. Decision-maker(s) would benefit from having available more informed contributions by the participants (compared to those obtained where no learning had taken place) to inform and support, their decision-making.

I.3. The argument of this thesis

The core argument of this thesis is that:

the design of a learning-enhancing public participation system must be informed by a learning theory.

There are many theories of learning available, grouped in somewhat arbitrary paradigms such as behaviourism, cognitivism, constructivism and humanism. Learning-Theories.com (2007) provides a useful and interesting overview of each of these paradigms with reference to relevant contributors. Specifically for the planning context, Hamilton *et al.* (2001) suggest that George Kelly's PCT (Kelly, 1955) is an appropriate one. According to Chiari and Nuzzo (2003) this theory can be framed within the constructivism epistemology.

Kelly's PCT poses that individuals form personal constructs to make sense of their complex environment. Learning (or experience as he calls it) is the successive revision of these constructs to improve their fit to the reality. Learning is an internal process that requires willingness and engagement and can be triggered by both, experiences of the physical world and social interaction. Hence, two dimensions of learning can be identified: an *individual dimension* corresponding to the exploration and rationalisation of individual experiences, tacit knowledge, prejudices and values; and a *social dimension* corresponding to gaining awareness of others' reasoning, arguments and concerns.

Tversky and Kahneman demonstrated that individuals are not fully rational with regard to the individual dimension of knowledge. Instead, when making decisions, they are influenced by multiple factors such as the vividness of particular traits or pieces of information, the order in which facts came up or were presented, past experiences, beliefs, desires, etc., which "twist" their reasoning and yield less rational/optimal choices (e.g. Kahneman, Slovic and Tversky, 1982).

To support decision-making and facilitate more rational decisions, decision support systems (DSS) were developed. Devised around 1964 (Power, 2007), this concept entered the planning realm in the mid-1980s, when computer graphics and processors started to meet the requirements imposed by (limited) spatial problems. Due to their focus on the spatial dimension, DSS applied to planning were called SDSSs.

Today SDSSs are well known planning support systems. They aim to improve the effectiveness of the decision-making process in ill- or semi-structured spatial problems and are explicitly designed as flexible, problem-solving environments where the decision problem can be explored, understood and redefined (Densham, 1991). In the course of this thesis, it is argued that these systems provide a rich framework for tackling the individual dimension of learning inasmuch as they provide an "experimental laboratory" for their users. In fact, an SDSS enables its users to investigate/recognise feasible decision alternatives and relevant decision criteria, to understand the relationships among these elements of the problem, to gain insights over the whole decision space by experimenting with alternative decision-making strategies and, when confronted with the likely consequences of these strategies, which the system predicts based on embedded data and decision models, to crystallise their individual preferences.

Spatial decision problems are typically multidisciplinary, so more than one decision-maker (or interest group) is typically involved in the decision-making process. SDSSs have been extended to support group decision-making (e.g. Jankowski *et al.*, 1997). However, group SDSSs (or collaborative SDSSs) fall short in making explicit the argumentation (and presuppositions) held by stakeholders in the process and, thus, have been criticised for not adequately supporting the interactive, communicative and consensus-building processes that should characterise spatial planning and decision-making practices (e.g. Gottsegen, 1995).

Argumentation systems (AS) have been conceived specifically to support multi-party debates. They present in a structured way the claims and the argumentation of individuals in collaboration/interaction (e.g. Tweed, 1998). As such, they promote knowledge sharing and enable swift acquaintance with the central points of the debate. In addition, they encourage participation and involvement in the debate as, by exposing the rationale behind the claims, they trigger critical thought and reactions either to support or challenge points of view. The aspects of providing new information and triggering critical thought are fundamental to the assertion made in this thesis that AS facilitate social learning.

AMs were introduced by Rinner (1999) to support spatial debates. Essentially these consist of a simplified AS (as AS are rather complex systems to use) linked to a map so that discussion contributions can explicitly refer to spatial entities and have a graphic representation on the map. This linkage brings up a double advantage. First, it makes the debate clearer as, by making explicit the spatial references, all users will be able to understand which entities are being addressed. Secondly, it facilitates the search/retrieval of discussion contributions about a specific location/spatial entity as discussion contributions associated with spatial entities are accessible from their graphic representation or referred entities. As a particularisation of AS, AMs are, like their roots, claimed to be and viewed as computer systems that facilitate social learning in the course of this research project.

Figure I.1 is a schematic representation of the foundations and structure of this thesis's argumentation. From one side, Kelly's learning theory informs us that both individual experiences and social interactions propel learning cycles by revealing facets of reality that conflict with current personal constructs. From the other side, SDSSs and AMs are argued to be systems that, respectively, facilitate the exploration, interpretation and making sense of individual experiences and encourage information exchange and knowledge sharing.

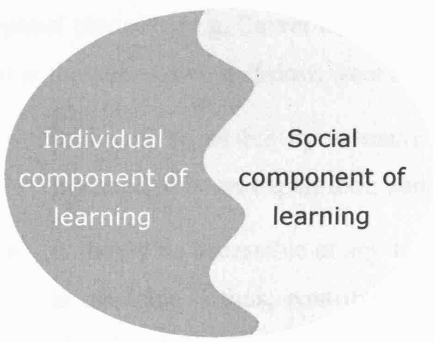


Figure I.1a - The two dimensions of learning according to George Kelly's PCT (1955).

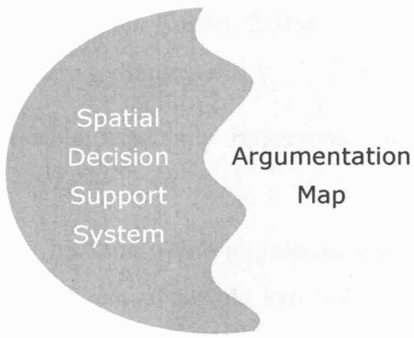


Figure I.1b - The pillars of this thesis: SDSS facilitate the individual component of learning and AM supports the social component of learning.

Figure I.1 – Schematic representation of the foundations of and rationale for this thesis.

Combining these two sides, one can conclude that, from the learning point of view, SDSSs and AMs are complementary in the context of spatial and environmental planning. Building on the argument enunciated at the start of this section, the following hypothesis can be logically derived:

the integration of an SDSS and an AM results in a learning-enhancing system adequate for public participation in spatial and environmental planning.

I.4. Objectives

The focus of this research is to investigate the veracity of the constructed hypothesis. For that, two main objectives were set:

1) design, develop and implement a public participation system that integrates an SDSS and an AM;

2) test the resulting system in a public participation-like setting to gain insight on how it is used by the public and to receive feedback on it, particularly on the achievement of its design goal of fostering and enhancing learning.

Consequently, the emphasis of this thesis is on developing and testing a conceptual framework for a web-based, public participation system conceived upon Kelly's theory of learning, and <u>not on developing or experimenting with philosophies or approaches to enhance learning</u>.

In harmony with the most recent developments in the field of system-based public participation in spatial planning (e.g. Carver *et al.*, 1996; Kingston *et al.*, 2000; Keβler, 2005a; Tang, 2006), right at the outset, two decisions were made about the system to implement:

- it should be usable by as many people as possible, especially laypersons – it is not intended to be an expert tool; and

- it should be accessible at any time and from any location where an Internet connection is available – thus, contributing to widening the circle of people involved in spatial planning decision-making processes and, hence, improving participatory democracy.

At this point it should be clarified that, since the final system will enable users to collaborate intellectually/interact without meeting at a specific place or discussing at the same time (via AM), the prototype can be classified as a *distributed* and *asynchronous* type of groupware software (DeSanctis and Gallupe, 1987).

For use as a case study to underpin system development, the problem of strategic planning of wind farm sites was selected. This selection is justified by the relevance of the problem in a time when the UK government encourages the development of renewable energies, and wind energy in particular, and also its controversial nature. Together these two aspects were considered elements capable of stimulating the interest of the public in participating and using the system. System testing was conducted in the School of Environmental Sciences, University of East Anglia.

I.5. Research questions

The first problem that must be addressed is the conceptual integration of an SDSS and an AM to create a learning-enhancing framework. As this is an original problem, this study addresses the following questions:

- Does it suffice to integrate an SDSS and an AM, or is there any other system/module that can/should be integrated to foster learning?
- In which order should the two systems be arranged to result in a better learning environment: the SDSS first, followed by the AM or *vice-versa*?
- How to establish the linkage between the SDSS and the AM (and other possible system/module(s)) both seamlessly and in a way that puts into practice Kelly's cyclical conception of learning?
- Which are the requirements that the SDSS and the AM (and the other possible system/module(s)) must fulfil knowing that the end-users will be laypeople?

After formalising the integration of the SDSS and the AM, the emphasis of the research switches to the technical side as the next goal is the implementation of a proof-of-concept system based on the conceived framework. At this state, questions such as the following are addressed:

- Are there any SDSS and AM readily available that fulfil the identified requirements?
- If there are readily available systems, does their underlying technology enable the sought integration? Moreover, is the required technology available so that these systems can be set up and used for the purpose of this research?
- If the required technology is not available, is it possible to adapt any of these existing systems without compromising the intended goal for the final system?
- How does the adaptation cost stand in relation to that of developing from scratch a "fit-for-purpose" piece of software?

- If developing from scratch is needed, how best to implement the identified requirements design- and technology-wise?

Once the implementation challenge has been tackled, the system testing phase aims to provide answers to the following questions:

- How do laypersons use the system? Have users fully explored the system or was there instead a noticeable preference for a particular component of the system (e.g. SDSS or AM)? Has the system been used as intended, particularly with respect to the devised linkage between the SDSS and the AM?
- What is the users' feedback on the system? Is it, as intended, usable by laypeople or are simplifications/improvements required in usability and the type/number of functionalities offered? Where have users encountered difficulties in using the system? Which improvements do they regard as more relevant/urgent?
- Does the system fulfil its goal, i.e. does the integration of an SDSS and an AM yield a system that fosters and enhances learning?
- Are contributions by the system's users collected in a format suitable for helping decision-maker(s)/instructing decision-making?

All these questions can be condensed into a single, more comprehensive research question:

how to design and build a web-based system combining an SDSS and an AM that serves public participation in spatial and environmental planning?

The word *serve* in the above question should be interpreted as "constitutes an adequate tool for", or in other words: 1) fosters and enhances learning; and 2) captures informed contributions from the participants on the topics that decision-makers need to formulate planning policies and make decisions.

I.6. The core contribution

Distilling from what is presented above, the core contribution of this research is the integration of an SDSS and an AM, two types of systems that, so far, have been regarded as independent and addressing different facets of the planning process. SDSSs support rationality and accountability in decision-making; while AMs are promoted as systems capable of supporting collaboration and the argumentative nature of planning. In a notable exception, Voss *et al.* (2004) allude to the integration of these systems. However, their efforts in this arena seem to be driven by the pragmatic challenge of integrating two pieces of in-house software rather than by a sound theoretical framework – which is lacking in their work. This thesis attempts to fill in this gap.

A theoretical framework for the integration of an SDSS and an AM is proposed that is founded on the learning needs of citizens contributing to the planning process and George Kelly's theory of learning. Beyond that, a design for the cohesive integration of an SDSS with an AM is ventured and a proof-of-concept system implemented and evaluated. Evaluation regarding the proposed theoretical framework is encouraging – i.e. the implemented system was found to enhance learning in the spatial problem at hand – and provides valuable insights and clear directives for future development of the implemented system.

I.7. Text organisation

The thesis organisation is outlined in Figure I.2. It comprises nine chapters, the first of which is the current one. In this chapter the problem area is identified, an overview of the thesis's argument is provided and the research objectives are clarified.

Chapter II examines the relevant literature and draws up the theoretical background for the research project. More specifically, it expounds on George Kelly's PCT, introduces the concepts of SDSS and AM and reports on state-of-the-art developments in these systems for public participation in spatial planning. While addressing SDSSs, the multi-criteria decision making (MCDM) methodology is introduced, along with relevant techniques to complete the process; these will become useful in the course of the thesis since the selected case study, as in most spatial planning problems, requires the consideration of multiple criteria in decision-making. The chapter culminates with the description of an innovative framework for public participation conceived by pulling together the three fields of literature reviewed earlier.

Chapter III analyses the proposed conceptual framework from the usage point of view and identifies functional requirements that should be satisfied by a proof-of-concept system implementing this framework. Requirements are identified with no particular spatial planning problem in mind as only in Chapter IV are the selected case study (spatial planning problem) and case study area introduced.

Chapter V describes the logical design devised for the proof-of-concept system and reports on the structuring process of the selected spatial planning problem to ensure that it can be tackled within the system's structure. Chapter VI focuses on the system's implementation. It provides details of its architecture and functionalities and a guided walkthrough.

The system's testing and loading phases are discussed in Chapter VII. It also describes the experiment carried out to evaluate, amongst other aspects, the achievement of the motivating goal: whether the integration of an SDSS and an AM indeed yields a learning-enhancing framework. Results of the experiment are presented and discussed in chapter VIII.

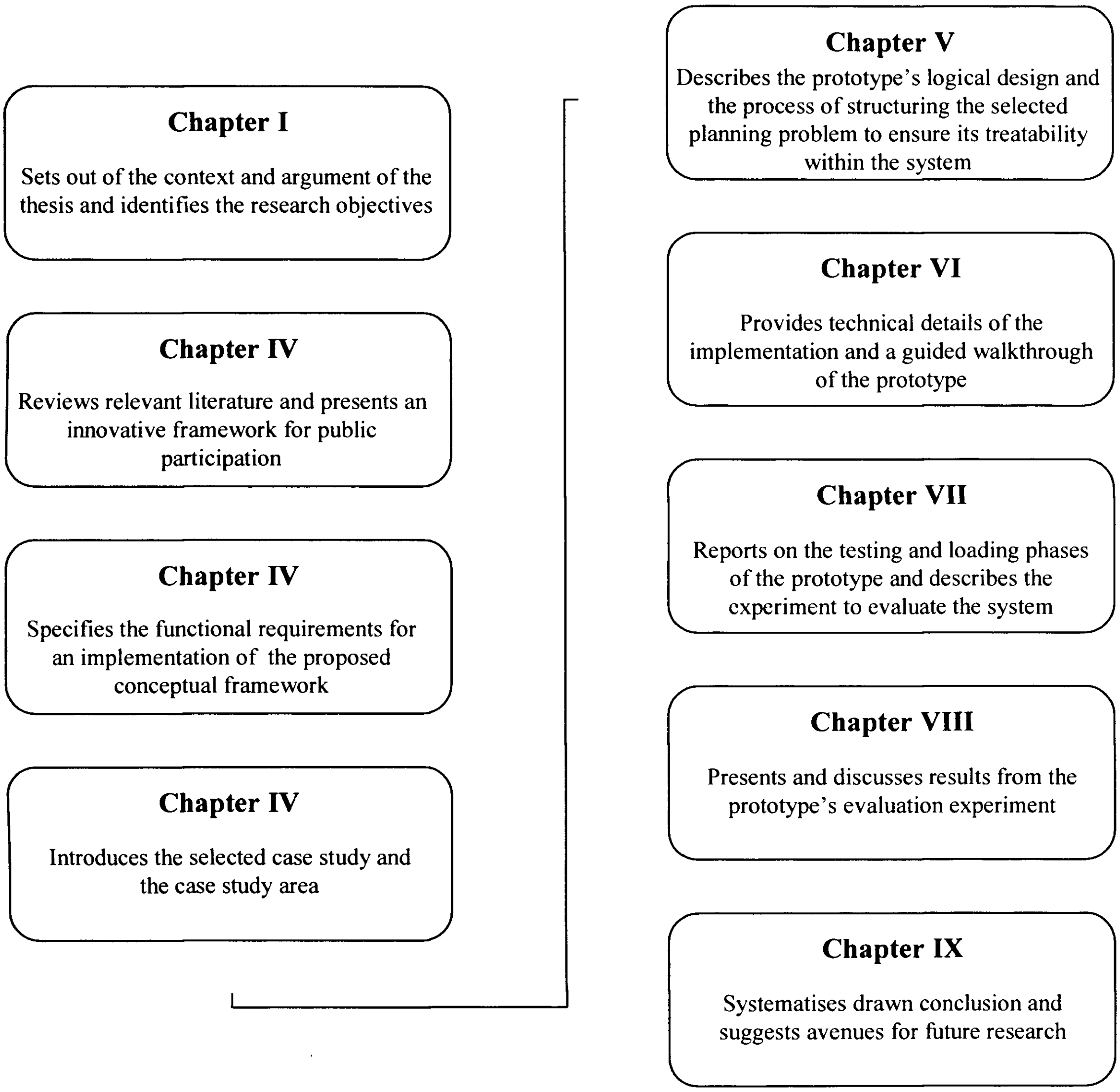


Figure I.2 – Thesis organisation.

Chapter IX completes this thesis by reviewing the work conducted, summarising the conclusions and placing this thesis's contribution in a wider context. It also suggests avenues for further research.

Chapter II

Learning and learning-facilitating systems for spatial planning

II.1. Introduction

Spatial planning problems are intrinsically complex: they have no definitive formulation, cross-disciplines and any solution has implications not easily envisaged. For this reason, several tools have been developed to support participants and decision makers (DMs) in the planning process. The ultimate aim of these tools is to guide the user through a learning process that will enable him/her to make better informed contributions/decisions.

This chapter analyses two types of these tools from the learning point of view: Spatial Decision Support Systems (SDSSs) and Argumentative Maps (AMs). Following the suggestion by Hamilton *et al.* (2001), George Kelly's Personal Construct Theory (PCT) is used as an appropriate learning theory with which to view the planning process as a learning system. The analysis concludes that SDSSs and AMs are complementary in terms of the learning component that they facilitate. Therefore, a new framework, integrating these two types of systems, is proposed. Built upon a theory of learning, the proposed framework is expected to enhance learning. To test this assumption, public participation in spatial planning was selected as the application context.

The structure of the chapter reflects this chain of ideas. Firstly, Kelly's PCT is presented with a particular focus on learning; applications to spatial planning are also reviewed. Secondly, the concept of decision support in spatial planning is visited and SDSSs are introduced and discussed in light of Kelly's PCT. Thirdly, communication support tools are presented, with an emphasis on developments for spatial planning, generically called AMs. As with SDSSs, these systems are examined from Kelly's learning theory perspective. Fourthly, a new conceptual framework for public participation in spatial planning is proposed; and, fifthly, the selected context to assess whether the proposed framework does indeed enhance learning is introduced. The chapter concludes with a synopsis of the information presented and a highlight of relevant conclusions/contributions.

II.2. Personal construct theory (PCT)

PCT is a theory by George Kelly (1905-1967). Kelly graduated in physics and mathematics but, while at University, his interests shifted to social problems. In 1931, Kelly completed his PhD at the University of Iowa on the common factors in reading and speech disabilities, and, the same year, started his professional career as clinical psychologist. In 1955, Kelly published a two-volume work, *The Psychology of Personal Constructs* (Kelly, 1955), where he expounds the full body of his theory. He subsequently published a large number of papers developing the theory, many of which were issued in collected form by Maher (1969).

This section provides an overview of PCT, explores the learning concept intrinsic to this theory and reviews applications of PCT to spatial planning. It concludes with a summary of PCT's key aspects for this research.

II.2.1. Fundaments of the theory

PCT is a theory of a person's personal inquiry: a notion of how people may launch from a position of admitted ignorance and reach out for knowledge not yet attained. The theory implements a philosophical assumption:

> "We assume that all of our present interpretations of the universe are subject to revision or replacement (...) there are always some alternative constructions available to choose among in dealing with the world." (Kelly, 1955: 15)

Kelly calls this philosophical assumption *constructive alternativism* and contrasts it with the epistemological assumption of *accumulative fragmentation* (knowledge is collected piece by piece). Fundamentally, Kelly invites people to substitute an analytic search for truth for a creative exploration of alternative constructions.

PCT is built upon two notions:

- individuals are incipient scientists: '*man-the-scientist*' (Kelly, 1955: 4); and

- the universe is real, integral (i.e. all events are interlocked) and is in constant motion.

II.2.2. The formal structure of the theory

Kelly was a keen geometer and formalised his theory following the model of Euclid's *Elements*. PCT is axiomatised in a *fundamental postulate* and eleven *corollaries*.

The *fundamental postulate* encapsulates Kelly's basic psychological premise:

> "A person's processes are psychologically channelized by the way in which he anticipates events." (Kelly, 1955: 46)

This postulate asserts that the theory's unit of concern is the person and the realm of concern is psychology, i.e. explanation of behaviour. It establishes that a person is a behaving organism in a continual process of living. Individuals, as scientists, aim to make sense of the universe and of life in order to gain control. They proceed in doing so by anticipating events. Anticipation is the 'push and pull' of PCT (Kelly, 1955: 49). The process of living is determined by the way the person adopts to anticipate events.

This postulate marks a rupture with previous ways of thinking. Individuals are not determined by inner drives as in Freudian psychoanalysis nor by environmental "stimulus" as in behaviourism; neither are they driven by a potential for self-realisation as humanistic psychologies suggest. Kelly sees individuals with initiative and gifted with imagination as choosing the ways in which they proceed to anticipate events. PCT is framed within constructivist epistemology, which is centred on the active participation of the subject in construing reality, rather than on representing reality or reflecting on it (Chiari and Nuzzo, 2003).

The *corollaries* elaborate Kelly's idea of individuals striving for personal meaning.

1. **Construction corollary**: "A person anticipates events by construing their replications." (Kelly, 1955: 50)

This corollary embeds Kelly's concept of universe: events never repeat or else they lose their identity. After a period of time, a person is able to detect a recurrent theme and construes by erecting a structure within which this recurrent event (theme, object) assumes meaning. In construing the person notes features that characterise the recurrent theme and are particularly uncharacteristic of others. Thus, a construct is a discrimination that one makes to perceive two events in a similar manner. Constructs can be concrete (e.g. pencil) or abstract (e.g. intelligent) and need not have a verbal label.

Constructs serve as interpretation of past events as well as 'working hypotheses' about events yet to be encountered. Bannister and Fransella (1986) expressively say:

> "(...) underlying our making sense of our world and of our lives, is our continual detection of repeated themes, our categorising of these themes and our segmentation of our world in terms of them". (Bannister and Fransella, 1986: 8)

2. **Individuality corollary**: "Persons differ from each other in their construction of events." (Kelly, 1955: 55)

Construing involves interpretation: it is a personal affair and is influenced by interests and values. This corollary ensures that for two persons to construct exactly the same event, they would have to have sought to anticipate the same event and have used the same approach to anticipate it. This corollary implies that each person lives ultimately in a unique world for it is uniquely construed and, thereby, uniquely experienced.

3. **Organisation corollary**: "Each person characteristically evolves, for his convenience in anticipating events, a construction system embracing ordinal relationships between constructs." (Kelly, 1955: 56)

This corollary says that personal constructs are grouped into a "construction system", where system implies a grouping of elements in which incompatibilities and inconsistencies are minimised. The grouping relationship is that of subsuming (inclusion). Subsuming can happen in two ways: one construct may subsume another as one of its elements by extending the cleavage intended by the other or by abstracting across the other's cleavage line (Kelly, 1955: 57). The construction system is personal since it consists of constructs of constructs.

Kelly notes that, rather than differences between individual constructs, the way a person systematically arranges the constructs is what characterises his personality (Kelly, 1955: 56). Bannister and Fransella (1986: 11) assert that it is this hierarchical organisation of constructs that makes a person's world manageable.

4. **Dichotomy corollary**: "A person's construction system is composed of a finite number of dichotomous constructs." (Kelly, 1955: 59)

With this corollary Kelly says that the construction system that canalises individuals' thinking is composed of a finite number of constructs, each following a dichotomous form (e.g. clear-confusing; thinking–feeling; warm–distant). This bipolar vision of constructs is at the basis of the Repertory Grid Technique (RepGrid), an interviewing technique that elicits individual cognition (i.e. personal construction systems) (Bell, 2003; Feixas and Alvarez, not dated; Fransella and Bannister, 1977; Jankowicz, 2003; Kelly, 1955).

Originally devised for clinical psychotherapy, RepGrid has been extensively applied in a variety of disciplines, including education (Kreber *et al.*, 2003), business and marketing (Enquire Within, 2006; Pike, 2005), information systems planning (Peffers *et al.*, 2003; Tan and Gallupe, 2006), human-computer interaction (Steed and McDonnell, 2003), knowledge acquisition (Gaines and Shaw, 1993) and spatial planning (Stringer, 1977). A recent book edited by Fay Fransella (2003) provides a good overview on how PCT ideas, and RepGrid in particular, have been put into practice.

5. **Choice corollary**: "A person chooses for himself that alternative in a dichotomized construct through which he anticipates the greater possibility for extension and definition of his system." (Kelly, 1955: 64)

Extension of the construction system means making it more comprehensive by exploring new areas that are only partially understood. Definition of the construction system makes it more explicit and clear cut about how constructs are applied to events and how they are linked to each other. Kelly poses that a person places relative values upon the ends of the dichotomous constructs: some values are transient; others are more stable, representing guiding principles (Kelly, 1955: 65). By placing this corollary, Kelly says that, when a person has to decide between the alternatives expressed in a construct they will choose the one that promises to develop further the usefulness of their construction system. Bannister and Fransella (1986: 13) note that this corollary creates either a tautology or a complete, integrated theory.

6. **Range corollary**: "A construct is convenient for the anticipation of a finite range of events only." (Kelly, 1955: 68)

This corollary implies that a construct has particular *foci of convenience*, corresponding to the set of things for which it was specifically developed, and a *range of convenience*, which comprises all things to which the user might find the construct applicable. Outside the range of convenience the construct fades into uselessness. According to Kelly, any particular construct may have a somewhat different range of convenience for each person who uses it, or even for the same individual on separate occasions.

7. **Experience corollary**: "A person's construction system varies as he successively construes the replications of events." (Kelly, 1955: 72)

Constructs are the basis for prediction (Kelly, 1955: 12). When a construct is placed upon an unfolding sequence of events, it can prove correct, misleading or turn out to be irrelevant. Thus, a person's construct system evolves by successively revising constructs in the light of unfolding events.

Kelly calls the successive construing and reconstruing of events *human experience*. By enriching the experience of life (and widening their awareness of the universe), a person increases their capacity to predict and make their world more and more manageable.

Kelly notes that confirmation of a construct may lead to just as much reconstruing as disconfirmation. The idea is that, by giving anchorage to some aspects of life, confirmation sets the person free to engage in explorations nearby (Kelly, 2003: 12). Kelly also notes that, like constructs, the construction system itself is open to revision (Kelly, 1955: 61).

8. **Modulation corollary**: "The variation in a person's construction system is limited by the permeability of the constructs within whose ranges of convenience the variants lie." (Kelly, 1955: 72)

This corollary addresses changes in the construction system, how a person deals with a revised construct. The permeability of a construct is its capacity to be used as a referent for novel events and to embrace new subordinate constructs within its range of convenience (Kelly, 2003: 13). Kelly compares permeable constructs to theories in science: flexible and welcoming new experimental ventures. In contrast, impermeable constructs are compared to hypothetical formulations: clear in scope and facing the prospect of either being kept intact at the end of the experiment or wholly shattered. Thus, permeable constructs are more likely to be durable and less shaken by the impacts of unexpected events. For example, the construct *good* versus *bad* is fairly permeable and its range of convenience can easily stretch to include new constructs. In contrast, the construct *fluorescent* versus *incandescent* is rather impermeable; outside the context of lighting it is rarely applied. Kelly notes that unless a new construct is admitted into the construction system as a permeable construct, it is likely to be ignored.

9. **Fragmentation corollary**: "A person may successively employ a variety of construction subsystems which are inferentially incompatible with each other." (Kelly, 1955: 83)

This corollary addresses change between successive constructs. A construction system is a hierarchy of subsystems that do not have to be logically intact: inconsistent subsystems are possible. Thus, a person's new construct does not have to be inferable from, or a special case within, their antecedent construct. From the modularity corollary, however, any proximate transition has to be consistent with the more stable (permeable) constructs of the system. Hence, inferential incompatibilities at a subordinate level have to be resolved at a superordinate (more permeable) level. In other words, when trying to make sense of the universe, the person continually climbs up and down their construction system. Kelly points out that it is this 'irrationality', or the uninferred fragment of the individual's construction system, that makes humankind capable of new ontological ventures (Kelly, 2003: 13).

10. **Commonality corollary**[1]: "To the extent that one person employs a construction of experience which is similar to that employed by another, his psychological processes are similar to those of the other person." (Kelly, 1955: 90)

This corollary complements the individuality corollary. Although people construe differently, the construction of their experience (the stock of outcomes from successively construing events) might result in similarities. Where two people have similar constructions of experiences, they think or behave alike – irrespective of the experiences they have been exposed to. This corollary has several implications for the study of cultural and group behaviour when "construction of experience" is understood as cultural background (Kelly, 1955: 93-4).

11. **Sociality corollary**: "To the extent that one person construes the construction processes of another, he may play a role in a social process involving the other person" (Kelly, 1955: 95)

Here Kelly establishes that, for a person to play a role in a social process involving another person, they must subsume into their own construction system the other person's construction system. Kelly illustrates this using the example of driving down a highway: collisions are avoided when a driver can understand another driver's perception of the situation, thereby being able to predict the latter's behaviour and, consequently, adjusting their own behaviour. An important implication is that, if one person cannot construe another's outlook, then this person cannot play a role in a social process.

Kelly emphasises three points with respect to construing another person's outlook. Firstly, to understand another person's outlook, one does not have to construe things as the other person does (their construction systems do not have to be similar). Secondly, to play a role in a social process, a person does not need to understand or subsume the other person's whole construction system, only a restricted range of it at the concrete level of the ongoing activity. Thirdly, understanding can be mutual but differences on the level, extent and depth of understanding might exist.

Kelly also notes that construing another person's outlook may reflect back upon, and have implications for, one's outlook (Kelly, 2003). That is, when influenced by aspects of another individual' construct system, a person might be led to revise their personal construct system and end up a good way from where they started. In a social process, this is valid for all role players

[1] Kelly (2003) corrects this statement saying that the world "psychological" should modify "similar" and not "processes" as in his original statement of this corollary. Thus, this corollary should read: "To the extent that one person employs a construction of experience which is similar to that employed by another, his psychological processes are similar to those of the other person".

and, if social interaction is encouraged, consensus and conflict resolution can be achieved as a result.

II.2.3. Learning in PCT

Kelly develops his theory using the term 'learning' no more than ten times (Fromm, 2003; Kelly, 1977). In spite of this, PCT is a learning theory. Kelly's vision is that learning is not a special class of psychological processes but synonymous with any and all psychological processes (Kelly, 1955: 75). Hence, instead of addressing learning as a topic within the theory, Kelly gives it a prominent position by building learning into the assumptive structure of the theory. He assumes that the course of all psychological processes is plotted by one's construing of events (construction corollary) and that a person's construct system evolves when anticipations or hypotheses are successively revised (experience corollary).

Kelly calls the successive construing of events *experience*. He systematises a unit of experience as a cycle embracing five phases: anticipation, investment, encounter, confirmation or disconfirmation and constructive revision, Figure II.1.

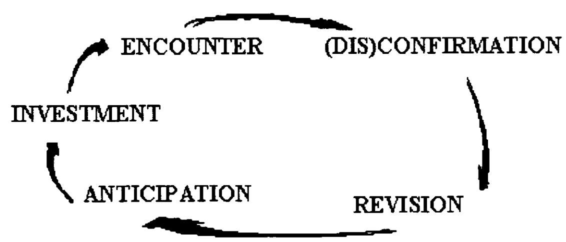


Figure II.1 - Kelly's full cycle of experience (after Kelly, 2003: 12).

- Anticipation, the forecasting of events, by individuals yields hypothesis formulation.
- Investment immerses the individual in the problem through self-involvement and commitment.
- Encounter is an open interaction between 'individual' and 'events': it requires an effort to understand events with an open mind.
- Confirmation or disconfirmation is the evidence-based assessment of what happened; it is an analysis of compatibility, subjectively construed, between prediction and observed outcome.
- Revision is the 'growth' of experience by taking stock of outcomes: the revision of constructs in the light of consequences.

Kelly stresses the importance of this last phase:

> "It is not what happens around him that makes a man experienced; it is the successive construing of what happens, as it happens, that enriches the experience of his life."
> (Kelly, 1955: 73)

Construction and experience corollaries are, thus, relevant to understand the thrusts for, and the process of, knowledge formation. The mechanisms of learning (reconstruing) are explained by the individual and sociality corollaries.

The individual corollary, by positing that constructs are personal, implies that constructs are impregnated with values and interests. Thus, to realise disparities between an experience (either a direct experience of the physical world or an indirect experience through informing media in any format, e.g. textual, graphical and aural) and the personal construct system (which embeds the values and interests), an individual must make sense of the experience. Because this involves introspection and self-analysis, and may not be a linear process, it may take more than one full cycle of experience. I will refer to this inwards process as the *individual component of learning*.

The sociality corollary states that individuals must construe the construction system of their partner to take part in a social process. This implies that an individual may perceive greater logic or usefulness in their partner's construction system and this may trigger reconstruing - the individual may change their own way of construing events. Thus, just like incongruence between experiences and values, 'conflict' between interacting individuals might lead to reconstruing of their construct systems. I will refer to this process as the *social component of learning*.

Thus, two components of learning - an individual and a social one – emerge from Kelly's PCT. To accommodate and reconcile these two dimensions, I am arguing that a learning-enhancing framework is necessary.

II.2.4. PCT and spatial planning

The idea of applying Kelly's PCT to spatial planning is not new. Beilin (2001), Harvey (1995), Pomeroy *et al.* (1983) and Ward and Russell (1981) are contributions to the literature on the topic. Despite their different application areas, these works share both the general motivation of understanding the perception and mental images that people form of the environment (environmental psychology) and a similar methodology: the RepGrip technique for capturing individuals' cognition. For example, to understand local urban knowledge in Ujung Pandang, a provincial city in Eastern Indonesia, Antweiler (2000) used the RepGrip technique in a study of intra-urban residential mobility.

In fact, the RepGrip technique is the most popular application of PCT and the sole example of applications found in the field of spatial planning. Different ways of applying the technique were nevertheless spotted. RepGrip is a technique for eliciting individual cognitions (personal construct systems) using elements (typically seven) whose nature depends on the application context. To elicit constructs (perceptions) of space, authors have used photographs (Pomeroy *et al.*, 1983; Antweiler, 2000), redevelopment plans (Stringer, 1977) and even GIS technology (Harvey, 1995).

An interesting piece of work on this subject was conducted by Stringer (1977). He stated that, for a plan to be accepted and successfully implemented, congruence must exist between the plan and the users' construction systems. This congruence can be achieved in four ways:

- by physical necessity or superior authority: individuals must adjust their construction system (reconstrue events) to accommodate the designer's plan;
- insidiously, by ascribing illusory or trivial properties to the plan in order to make it fit the public's view of the world;
- by appraisal of the public's various construct systems and leaving to the designer the burden of making their construction system (used to design the plan) maximally congruent with those of the public; this is mostly a one-way contact, where people answer questions asked by the designer; and
- through an educative, two-way communication process that makes intelligible to the public the complexities of the designer's construct system and enables the designer to construe a general understanding of people's environmental value systems.

These four ways effectively correspond to different levels of involvement in the design process. Stringer (1976; 1977) describes how RepGrid elicited peoples' perceptions and evaluations of redevelopment proposals; the ultimate goal being to use extracted meaning to inform the designer's activity and, thus, increase the congruence between the plan and the potential users' construction systems.

Stringer's work was conducted in the context of redeveloping the famous Triangle Victorian shopping centre, adjacent to the site of the old Crystal Palace in South London. He supplied respondents with alternative redevelopment plans for the Triangle, prepared by the local planning authorities, and invited them to construe the proposals. An interesting conclusion by Stringer was that his study "did precarious little" for the respondents (Stringer, 1977: 304). Citizens did not "move forward to a more understanding and richer relation with one another and with those who work for them" (Stringer, 1977: 305). This shortcoming can be understood as a consequence of the lack of social interaction amongst members of the public and between them and the designer. As RepGrid was conceived to capture the dimensions and structure of personal meaning, it can be argued that it exclusively tackles the individual component of learning.

II.2.5. Summary

The essence of PCT is the human quest to interpret the 'booming, buzzing confusion' of life. The full body of the theory comprises one fundamental postulate and eleven corollaries, but only four corollaries are explicitly used for the purposes of this thesis. These are the construct corollary, the experience corollary, the individual corollary and the sociality corollary.

The construct corollary states that individuals, in a condition of relative ignorance but aspiring to predict the future, proceed by giving meaning to (construing) manifestations of reality. Constructs are the grounds for prediction and they are validated or found misleading as the future reveals itself. Whenever a construct fails to yield a working prediction, individuals need to reconstrue to evolve (look for other ways to make sense of the experiences that formed the basis of the original construct); if reconstruing does not take place, individuals would do no more than 'collide' with a series of events - experience corollary.

Reconstruing is propelled by making sense of new experiences of reality - individual corollary – and by interacting with other individuals - sociality corollary. Hence, a learning-enhancing framework should facilitate these two mechanisms of learning.

Applications of PCT to spatial planning are limited to the use of the RepGrid to elicit mental constructs from individuals. The idea is to use this cognitive data to guide planners and designers in adjusting their plans to the public's construct systems, so they will not have to alter their construct systems (and actions) to accommodate the designer's plans.

II.3. Decision support in spatial planning

This section addresses decision support in spatial planning and is divided into four modules. Beginning with a justification for decision support, it then introduces the concept of decision support and presents a methodology and techniques used for that purpose. Next, it focuses on computer systems specifically developed to support decision-making for spatial problems: the concept, origins, architecture, evolution and applications are reviewed. Finally, these systems are discussed in light of Kelly's PCT. The section terminates with a summary of the information presented.

II.3.1. The need for decision support

A number of authors have investigated the phenomenon of human reasoning (see Evans (1990) for an overview). Within the behavioural approach, Amos Tversky and Daniel Kahneman demonstrated that people make statistical inferences and judgements based on "heuristics" or simple rules or thumb which, while appropriate in some contexts, result in a large number of errors and biases on many occasions (Tversky and Kahneman, 1982c).

Evans (1990: 91) argues that many biases "are caused by *pre-attentive* or *preconscious* heuristic processes which determine selective encoding of psychologically 'relevant' features of the problem" (e.g. add to, drop, or alter the premises given). This selective process can occur either at the formation of the mental representation of the information presented or in the manner in which information is subsequently processed. It is determined by a number of factors:

- availability of information that is attended to and thought about when performing the cognitive task (Tversky and Kahneman (1982a) provide a detailed description of this *availability bias*);
- aspects of the problem that are perceived as relevant (Tversky and Kahneman (1982b) discuss the '*base rate fallacy*', a phenomenon closely related to this factor while Kahneman and Tversky (1982) attempt to explain it in terms of the *representativeness heuristic* and Evans (1984) discusses the factors that determine perceived relevance);
- vividness (Nisbett and Ross, 1980) and salience (Taylor and Thompson, 1982) of evidence; and
- aspects of the problem or associated evidence that a subject can retrieve from memory and come to think about (working memory capacity).

Direct experience and beliefs can also be a source of biases and errors. The literature shows that subjects can reject a logically valid conclusion that is unbelievable or accept an invalid conclusion that is believable - this is known as *belief bias* (Evans *et al.*, 1983; Revlin *et al.*, 1980).

Kahneman *et al.* (1982) indicate that biases are likely to be prevalent in real life and expert decision-making. Moreover, authors in the field of social cognition have claimed that biases in inductive reasoning can lead subjects to hold beliefs about themselves, about other people, or even about the nature of the social world, that are premature and in many cases erroneous (Nisbett and Ross, 1980; Ross and Anderson, 1982).

To reduce or eliminate the impact of biases in reasoning, decision-making and problem solving, debiasing procedures can be applied. Fischhoff (1982) offers a categorisation of some debiasing strategies according to where the responsibility for the bias lies: on the judge, on the task or on some mismatch between the two. Evans (1990) proposes four higher-level approaches:

- replacement of human intuition by a formal procedure, partially or completely – this approach has inspired the development of expert systems, i.e. computer programs that emulate the reasoning of human experts (see, for instance, Jackson, 1999);
- education and training to improve reasoning ability;
- improving the design of the environment in which the human operates; and
- development of interactive decision aids.

The following sections focus on the latest approach. They introduce a methodology, techniques and a type of interactive computer system to help individuals explore decision problems and develop informed judgements for decision-making.

II.3.2. Decision support: definition, methodology and techniques

II.3.2.1. Definition

There is no definitive definition of decision support, but a well accepted definition is that of Bernard Roy (1985)[2]. He defines decision support as the activity of those who, based on models clearly explicit although not necessarily formalised, help obtain elements of responses to the questions posed by stakeholder of a decision process, or simply facilitate a behaviour that will increase the consistency between the evolution of the process and this stakeholder's objectives and value system. Thus, the role of decision support is not to discover the solution, but to assist the decision research process. This thought, characteristic of 'the European school' of decision-making contrasts with that of the 'American school', which considers that decision support should culminate in providing the DM with a good decision (Roy and Vanderpooten, 1996: 27).

II.3.2.2. Multi-criteria decision making (MCDM)

Decision makers (DMs) faced with a spatial problem often must consider multiple, conflicting objectives for its solution (Massam, 1980; Nijkamp, 1979; Thill, 1999). MCDM provides a methodology for guiding them through the critical process of articulating the objectives for, and defining the values that are relevant to, decision-making and using systematic techniques to recommend a course of action (Hwang and Yoon, 1981; Malczewski, 1999a, 1999b; Roy, 1985; Roy, 1996; Roy and Vanderpooten, 1996; Yoon and Hwang, 1995).

---

[2] Bernard Roy is a French author and, as such, refers to decision support as "l'*aide à la décision*". When his 1985's book was translated to English (Roy, 1996), "l'*aide à la décision* " was translated to "decision aiding".

Two classes of MCDM can be distinguished: multi-objective decision making (MODM) and multi-attribute decision making (MADM). MODM generates alternatives and searches for the "best" decision amongst an infinite or very large set of alternatives. Each alternative is defined implicitly in terms of decision variables and evaluated by means of objective functions. In contrast, MADM requires choices to be made among alternatives described by their attributes. Alternatives are both predetermined and limited in number; attributes are explicitly known and are used as both evaluation criteria and decision variables. Briefly, MODM is appropriate for design processes in *continuous* decision problems, whereas MADM is appropriate for selection in *discrete* decision problems.

Participation in spatial planning typically involves stakeholders in opining on a limited set of decision alternatives (ideas, plans, projects, etc.). Hence, MADM is appropriate for this context. The following paragraphs focus on the MADM methodology: thus, whenever MCDM is used, the meaning is MADM.

II.3.2.3. MADM: methodology and techniques

MADM involves a sequence of activities that starts with problem definition and ends with recommendation. Figure II.2 outlines this process, integrating it with decision-making phase model introduced by Simon (1960): intelligence (problem framing), design (exploratory phase) and choice (decision).

By virtue of its non-linearities (e.g. sensitivity analysis may prompt the revision of inputs), the MADM methodology is also presented as a combination of two steps: construction and exploitation (Guitouni and Martel, 1998). Construction includes information gathering and the modelling process; exploitation includes calculation, analysis of results and recommendation.

Problem definition

A problem is a perceived difference between the desired and the existing state of a system (Malczewski, 1999a). Once recognised, problem definition is crucial for its resolution. Roy (1985) categorises decision problems into four reference problematics: description, choice, sorting and ranking problematics. Each problematic determines the type of decision rule to apply to obtain a recommendation.

Evaluation criteria

With the problem identified, MADM requires the definition of evaluation criteria. This involves specifying (Malczewski, 1999a):

- a set of objectives that reflect all the concerns relevant to the decision problem; and

- measures for achieving those objectives, called *attributes*.

An objective might need various attributes to provide a complete assessment of the degree to which it is achieved. For instance, the objective "minimise local impacts by a wind farm" might require an assessment of noise, shadow flicker and property value impacts.

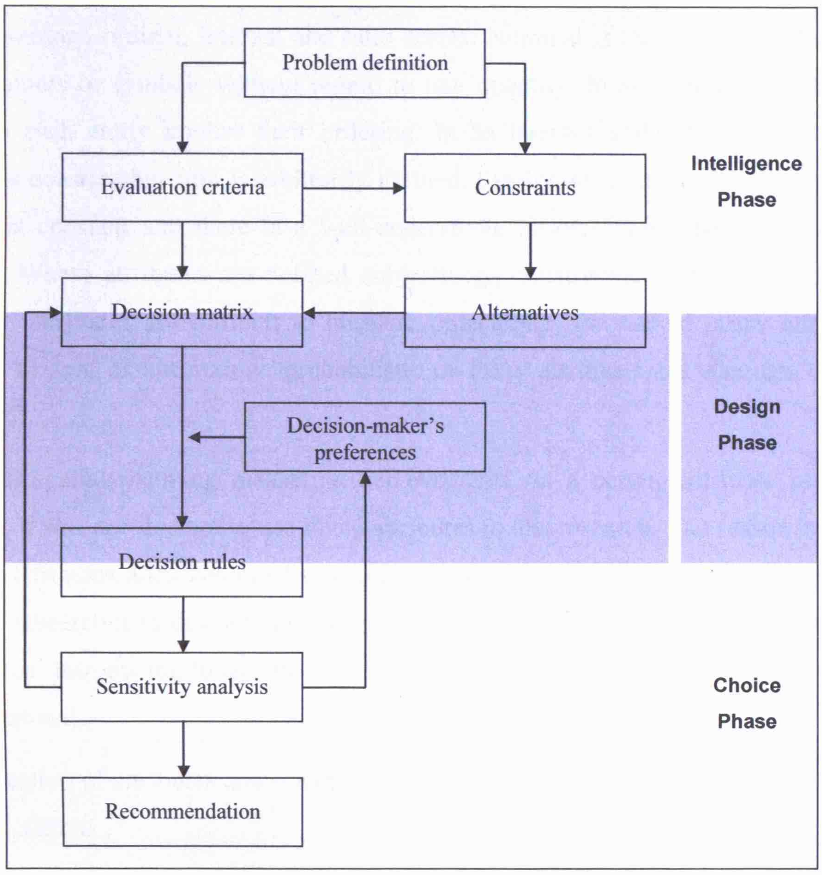


Figure II.2 - The MADM methodology (adapted from Malczewski, 1999a).

A variety of techniques can be used to construct/elicit a set of evaluation criteria including examination of relevant literature, analytical studies and a survey of opinions. Clearly, different techniques will bring out different sets of attributes. For this reason, various authors have suggested that a combination of techniques result in a preferable approach (De Marchi *et al.*, 2000; Keeney and Raiffa, 1976; Malczewski, 1999a).

Keeney and Raiffa (1976) provide guidelines for selecting a set of attributes. Each set should be *complete*, *operational*, *decomposable*, *non-redundant* and *minimal*. A set of attributes is complete if it covers all the important aspects of the problem; it is operational if it can be meaningfully used in the decision-making process; it is decomposable if the process of evaluation can be simplified by breaking it down in parts; it is non-redundant if it avoids double counting of impacts; and, finally, it is minimal if it keeps the problem as small as possible.

Individual attributes should be *comprehensible* and *measurable*. An attribute is comprehensible if it clearly indicates to what degree the associated objective is achieved; it is measurable if (1) a measurement scale can be established to measure the degree to which the objective is achieved; and (2) it is practical for the DM to assess various levels of the attribute.

For measuring the level of achievement of a particular objective, various scales are available including nominal, ordinal, interval and ratio scales. Nominal is the least restrictive scale and assigns numbers or symbols without regard to any quantity. In an ordinal scale the numbers assigned to each entity implies their ordering. In an interval scale measure, the amount of difference is constant but zero is arbitrarily defined. Finally, in a ratio scale, the amount of the difference is constant and there is a well-understood, absolute zero that any scale measure would use. Where attributes are defined subjectively, constructed (subjective) scales can be used. When attributes are difficult to measure objectively, the use of proxy attributes is an alternative. In case of uncertainty, probabilistic or fuzzy attributes are adequate (Keeney and Raiffa, 1976).

Although in spatial planning measuring achievements on a certain attribute often involves uncertainty, it was decided not to use fuzzy attributes in this research. The reason is that dealing with fuzzy attributes adds complexity to the decision-making process and, since the ultimate goal of this research is to develop a learning-enhancing system, there is no fundamental need to consider them. Introducing fuzzy attributes might become of interest when the intended system is fully functional.

The specification of attributes and selection of measurement scale will be referred to as *criteria operationalisation.*

Alternatives

Keeney (1996) suggests a *value-focused* approach to generating alternatives. This means that alternatives should be generated in whichever way best achieves the evaluation criteria (values) specified for the decision problem. However, in the real-world, very few problems are unconstrained; constraints reflect restrictions imposed on the decision space. For instance, wind turbines should not be installed in sites adjacent to residential areas. Consequently, generation of alternatives typically requires careful examination of the problem to identify uniquely the set of *feasible alternatives.*

Feasible alternatives need to be assessed on identified attributes. *Performances on attributes*, i.e. the degree to which the objectives underlying the attributes are met, are the basis for comparing alternatives. This information is stored in the so called *decision matrix*, where rows represent feasible alternatives and columns attributes.

To reduce the complexity of subsequent stages of the methodology, various techniques can be applied to simplify the decision matrix. One such technique is dominance analysis whereby all dominated alternatives – those that are worse than another alternative on at least one attribute (evaluation criterion) and equal to it on all remaining attributes - are eliminated (Malczewski, 1999a; National Economic Research Associated, 2000).

Decision maker (DM)'s preferences

At this point in the methodology, a DM's preferences must be elicited to be incorporated into the decision rule. Preferences are typically expressed in terms of weights assigned to evaluation criteria that indicate their importance relative to other criteria under consideration. The larger the weight, the more important is the criterion for decision-making. Weights are usually standardised to sum to one.

A variety of criteria weighting techniques exists. Two fundamental approaches are to:

- elicit preferential information from the DM; and
- infer the preference model from exemplary decisions made by the DM on some reference alternatives. This approach is called preference disaggregation.

Ranking, rating, trade-off analysis and pairwise comparison are techniques within the first approach. Ranking methods require the DM to arrange the criteria under consideration in rank order; then use multiple formulae to calculate criteria weights (Barron and Barrett, 1996; Edwards and Barron, 1994; Stillwell *et al.*, 1981). Rating methods require the DM to estimate weights on the basis of a pre-determined scale, typically from 0 to 100. Examples include the point allocation technique and the ratio estimation procedure (Easton, 1973). Trade-off analysis makes direct assessments of trade-offs between pairs of alternatives; the swing weight method introduced by Edwards and Barron (1994) implements this approach. Finally, the analytical hierarchy process (AHP) elicits criteria weights from pairwise comparisons of alternatives (Saaty, 1980).

Specifying criteria weights is often an iterative process that can be cumbersome (Zopounidis and Doumpos, 2002: 178). To facilitate this process, various software programs have been developed, such as MACBETH (Bana e Costa and Vansnick, 1994) and LOGICAL DECISIONS (Logical Decisions, 2007). Yet, the success of the procedure depends on the willingness of the DM to provide the required information and the ability of the decision analyst to elicit it efficiently. This makes the preference disaggregation approach attractive to various authors. Jacquet-Lagrèze and Siskos (2001) present a panorama of preference disaggregation methods and report on some applications.

The two approaches share a common objective: to determine the DM's preference model. Exploring this aspect, aggregation-disaggregation procedures have been proposed to validate the DM's preference model (Bana e Costa and Oliveira, 2002; Densham, 1990; Dias *et al.*, 2002). The idea is that differences between the preference model constructed based on elicited weights and the estimated global preference model resulting from the disaggregation approach prompt the DM to refine stated preferences or the holistic evaluation of reference alternatives.

No technique is superior to the others. Malczewski (1999a) suggests that the selection of a technique should be guided by the application context. Similarly, Mustajoki *et al.* (2004) stress the appropriateness of the selected technique to the context and highlight that improper use of preference elicitation techniques leads to incorrect results.

Decision rules

Decision rules are aggregation functions that integrate information on alternatives (performances on attributes) and the DM's preferences to produce an overall assessment of alternatives. They are the basis for a recommendation, Figure II.2.

Various categorisations of decision rules have been attempted. Guitouni and Martel (1998) identify three approaches: (*i*) single synthesising criterion without incomparability; (*ii*) outranking synthesising criterion, and (*iii*) interactive local judgements with trial and error. Major techniques within the first approach include Multi-Attribute Utility/Value Theory (MAUT and MAVT respectively) (Keeney and Raiffa, 1976). The objective of these techniques is to model and represent the DM's preferences into a utility/value function, which can be additive, multiplicative, etc. The additive form is most commonly used:

$$U(a_i) = \sum_j w_j \, u_j(x_{ij}) \tag{1}$$

where,

a_i: alternative i;

w_j: standardised weight of the evaluation criterion (attribute) j;

u_j: the marginal utility function corresponding to the evaluation criterion j; and

x_{ij}: the performance of alternative i with respect to the evaluation criterion j.

Techniques having MAUT/MAVT as their basis, such as UTA (Jacquet-Lagrèze and Siskos, 1982) and UTADIS (Zopounidis and Doumpos, 1999), also fall within this first approach.

A technique similar to MAUT/MAVT, but not so robust theoretically, is simple additive weighting (SAW) (Churchman and Ackoff, 1954; Hwang and Yoon, 1981; Keeney and Raiffa, 1976; Voogd, 1983). SAW uses standardised performances on evaluation criteria instead of utilities/values derived from the value or utility function. This greatly simplifies the decision-making process and, perhaps, justifies why it is the most used MADM technique.

Other popular techniques in the first approach are the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) and AHP. The former is a particularisation of the so-called Ideal Point Method (Hwang and Yoon, 1981); the latter uses pairwise comparisons of alternatives along with a semantic and ratio scale to access the DM's preferences and construct an overall priority rating (Saaty, 1980).

The second approach, using an outranking synthesising criterion, includes the technique ELECTRE I (ELimination Et Choice Translating REality) and all its derivatives: ELECTRE IS, II, III, IV, TRI (Roy, 1991; Roy and Bouyssou, 1993) and PROMETHEE (Brans and Vincke, 1985). Other techniques based on the same concepts include ORESTE, REGIME and MELCHIOR. Vincke (1989) provides an overview of these techniques and Guitouni and Martel (1998) refer to some applications.

To choose an appropriate technique, Guitouni and Martel (1998) recommend the consideration of seven factors: 1) who is/are the DM(s); 2) the DM's way of thinking and his/her level of comfort with a specific technique; 3) the decision problematic; 4) the quantity and quality of the information available; 5) the compensation degree accepted (all MADM techniques embed a compensation logic, either partial or total); 6) the fundamental hypothesis of the technique; and, finally, 7) existence of a decision support system.

Sensitivity analysis

Sensitivity analysis is a procedure for determining how the recommended alternative (or technique) is affected by changes in the inputs to the analysis (initial data and DM's preferences). If changes in inputs do not significantly affect the outputs, the recommendation is considered robust. When the current result is found unsatisfactory, the problem should be re-formulated, either by integrating new information or by revising the DM's preferences.

Sensitivity analysis can also be seen as an exploratory process whereby the DM can investigate and learn how the various decision elements interact to determine the recommended (the most preferred) course of action. Furthermore, it can be viewed as an indirect way to incorporate uncertainty into the decision-making process (Malczewski, 1999a). A particular example relates to criteria weighting: when a stakeholder with no experience of a decision problem tries to state their preferences for the evaluation criteria, it is likely that doubts will arise. By enabling the DM to experiment with various inputs and analyse likely consequences, sensitivity analysis can be used to crystallise individual preferences.

A number of studies have demonstrated that different decision rules produce inconsistent results for the same problem (Carver, 1991; Hobbs *et al.*, 1992; Hobbs and Meier, 2000; Simão, 2000; Voogd, 1983). Consequently, experimenting more than one decision rule should be part of the sensitivity analysis.

Recommendation

A recommendation for future action emerges from a decision rule and associated sensitivity analysis. From the paradigm of MCDM, it is important to stress, though, that the recommended solution is not the *optimal* solution but one that the DM finds satisfactory.

II.3.3. Spatial Decision Support Systems (SDSSs)

Most spatial problems are intrinsically complex and no definite problem statement is available beforehand. Insight into what the problem is and how it might be solved is usually gained incrementally, during successive problem exploration cycles. These problems are termed wicked (Rittel and Webber, 1973), ill- or semi-structured (Gorry and Morton, 1971), or nonprogrammable (Simon, 1960).

Analytical procedures (such as MADM) require that the problem is defined and the objectives for its solution articulated fully. Therefore, such procedures do not provide an adequate environment to deal with spatial problems. SDSSs are designed to offer a more satisfactory environment. The concept, architecture and evolution of SDSSs are reviewed over the next few sections.

II.3.3.1. Concept and origins

The idea behind the development of SDSSs was to use computer-based systems to tackle the structured part of the spatial problem and to provide assistance for the DM to deal with the intangible aspects and the unstructured part. Hence, SDSSs were proposed as geoprocessing systems offering flexible, problem-solving environments wherein the user could analyse geographical information, model scenarios, incorporate judgements and assess outcomes. The concept emerged in the mid-1980s (Armstrong *et al.*, 1986), inspired by discussions on generic decision support systems (DSS). Densham (1991) clearly marks these roots, noting that SDSSs have evolved in parallel with DSS, but lagging by 10 or 15 years. The development of computer technology was a key determinant in the development of SDSSs, since limited graphics and processing power inhibit the handling of spatial applications.

II.3.3.2. Definition and architecture

Densham (1991) defines SDSSs using six characteristics and four distinguishing capabilities and functions. The characteristics are those suggested by Geoffrion (1983) to define DSS: 1) explicitly designed to solve ill-structured problems; 2) powerful and easy-to-use interface; 3) ability flexibly to combine analytical models with data; 4) ability to explore the solution space by generating alternatives; 5) capability to support a variety of decision-making styles; and 6) facilitating interactive and recursive problem solving. The capabilities and functions are: 1) acquisition and management of spatial data; 2) representation of geographical objects and their spatial relations; 3) performance of spatial analysis; and 4) generation of output in various spatial forms, including maps.

More recently, Malczewski, (1997) defined SDSSs as interactive, computer-based systems "designed to *support* a user or group of users in achieving a higher *effectiveness* of decision making while solving a *semi-structured spatial decision problem*".

Various architectures have been proposed for SDSSs (Armstrong *et al.*, 1986; Carver, 1991). A generic architecture contains three major components, Figure II.3:

- a database management system (DBMS) that contains a geographical database;
- a model base management system (MBMS) containing libraries of models that implement analysis procedures and modelling capabilities; and
- a dialogue generation and management system (DGMS) containing mechanisms for data and information input and output of maps and graphics and tabular reports.

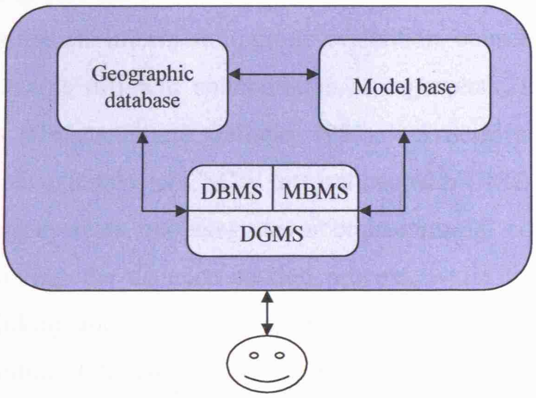


Figure II.3 – Components of an SDSS (adapted from Malczewski, 1999a).

The spatial capabilities of an SDSS are typically powered by a Geographical Information System (GIS). GISs are computer systems that facilitate the input, storage, retrieval, manipulation, analysis and output of geographically referenced data, and allows the integration of this data with non-spatial (attribute) data (Maguire, 1991). While GISs are often used to support decision-making in planning and land use, they are distinct from SDSSs because they lack analytical modelling capabilities and do not support multiple decision-making strategies (Armstrong and Densham, 1990; Densham, 1991). Hendriks and Vriens (2000: 86) explain this difference by stating that "GISs look at data, whereas SDSSs look at problem situations".

A particular type of SDSSs are multi-criteria SDSSs (MC-SDSSs) that result from integrating MCDM techniques into the model base to support DMs with problems that require making trade-offs between criteria. MC-SDSSs are extensively covered in the literature (e.g. Ascough II *et al.*, 2002; Carver, 1991; Hill *et al.*, 2005; Jankowski, P, 1995; Malczewski and Rinner, 2005; Malczewski, 1999a; Mysiak *et al.*, 2005; Thill, 1999).

II.3.3.3. Evolution: from single-user to collaborative SDSSs

A major thrust for research and development activity on SDSSs was a research initiative funded by the USA National Center for Geographic Information and Analysis (NCGIA) - Initiative 6: Spatial Decision Support Systems (SDSS), begun in 1990. This initiative lasted for three years and the focus was placed on the development of single-user SDSSs.

In 1993, Marc Armstrong noted the mismatch between the single-user SDSSs model and the group-based approach to decision-making in spatial planning; a consequence of the plurality of interests involved in spatial problems and required interdisciplinary approach to solve them due to the fragmentation of knowledge into fields of expertise. Therefore, he argued for the integration of SDSSs (and GISs) with computer supported cooperative work (CSCW) environments (Armstrong, 1993; 1994).

CSCW is a type of groupware for human collaboration (Laurini, 1998, 2001b): exchange of textual, numerical and graphical information, group evaluation, consensus building and voting. Different technologies enable different collaboration arrangements: same/different times and same/different locations (DeSanctis and Gallupe, 1987; Jankowski and Nyerges, 2001). The literature contains multiple examples of CSCW integrations with GISs. Shiffer (1992) describes two collaborative planning systems, one integrates a "brainstorming" component with the ability to manipulate criteria during the decision-making process, while the other integrates video sketching tools with a linking and annotation capability for associative information structuring. Faber *et al.* (1994) combine GIS and electronic meeting software to provide the ability to annotate, share and analyse spatial information. Jones *et al.* (1997) combine a user interface management system, knowledge-based techniques and agent support for group-work in an existing single-user GIS. Churcher and Churcher (1996; 1999) present a prototype for real time GIS conferencing.

With regard to SDSSs, the integration of these systems with CSCW was at the forefront of research efforts in collaborative spatial decision making (CSDM). In 1995, another NCGIA-funded initiative was launched to coordinate the research agenda on CSDM (Initiative 17: Collaborative Spatial Decision-Making). The emphasis was put on tool development and tool use (Densham *et al.* 1996).

As a consequence of this initiative, today there exists a well-established and growing body of literature on the theory and applications of CSDM. At the theoretical level, the state of the art is possibly Jankowski and Nyerges (2001)'s comprehensive framework for CSDM development known as Enhanced Adaptive Structuring Theory, version 2 (EAST2).

At the application level, various highly interactive CSDM environments have been developed in a variety of domains, including land resource management (Faber *et al.*, 1994; 1998), habitat restoration (Jankowski *et al.*, 1997), land use planning (Feick and Hall, 1997), water resource planning (Jankowski *et al.*, 2006; Nyerges *et al.*, 2006). More examples are provided in Malczewski (1999a) and Jankowski and Nyerges (2001).

Furthermore, non-spatial decision analysis tools were extended to assist group decision-making and integrated with (multi-criteria) group decision-making methodologies to tackle spatial problems (see, for instance, work by Malczewski *et al.* (1997) on land suitability/use analysis and by Hämäläinen *et al.* (2001), Mustajoki *et al.* (2004; 2006) on water resource management). Beyond that, multi-criteria decision analysis tools were combined with social techniques yielding "social multi-criteria evaluation" (De Marchi *et al.*, 2000; Munda 2004; Munda *et al.*, 2006).

II.3.3.4. Web-based SDSSs

The advent of the World Wide Web and the Internet has played a major role in the development of collaborative SDSSs. On the one hand, it enabled the implementation of heterogeneous processing environments, with flexibility and portability benefits, amongst others (Batty and Densham, 1996). On the other hand, it potentially extended the decision-making process to all stakeholders, regardless of spatial and temporal constraints.

Li (2006) reviews the web-technologies suitable for developing and implementing web-based collaborative SDSSs and gives examples of implementations. He concludes that current implementations, while focussing on sharing information and presenting results, lack more complex decision-making techniques and tools. In fact, a significant amount of effort has been vested by researchers in the sub-fields of planning support systems and public participation GIS (PPGIS). Here the concern is not so much with offering decision-making support, but rather with the integration of multi-source datasets and enabling DMs, lacking advanced knowledge of geospatial technologies, to explore and understand spatial solutions and/or qualitatively participate in shaping their environment (see, for instance, work by Al-Kodmany, 1999b; 2001; Batty *et al.*, 2001; Gouveia and Câmara, 1999; Hudson-Smith *et al.*, 2002; Kingston *et al.* 1999; 2000; Shiffer, 1995; 2001). Geo-collaboration has also attracted researchers' interest (Cai, 2005; Dragicevic and Balram, 2004; MacEachren and Brewer, 2004). Here the focus is on facilitating group work with geospatial information, namely through mediating understanding and support negotiation, rather than providing explicit support for choice amongst alternatives.

Carver and Peckham (1999) and Rinner (2003) review web-based SDSSs that provide explicit support for decision-making. For small group collaboration, and requiring the presence of a facilitator/moderator, a notable implementation by the German Fraunhofer Institute is CommonGIS (previously Descartes) (Andrienko and Andrienko, 1999; 2001; Andrienko, G. *et al.*, 2003). This application has been extended by Jankowski *et al.* (2001) and Rinner and Malczewski (2002).

For public participation (not requiring a facilitator), four remarkable developments are:

- Open Spatial Decision Making (OSDM) by Steve Carver and his colleagues at the Centre for Computational Geography, University of Leeds (Carver *et al.*, 1996, 1997; 2002b);
- Spatial Understanding and Decision Support System (SUDSS) (Jankowski and Stasik, 1997; 2006; Stasik and Jankowski, 1997);
- Multicriteria-GIS (MC-GIS) (Malczewski, 1999a; Menegolo and Peckham, 1996); and
- VegMan by Zhu *et al.* (2001).

The key idea behind the first two developments is providing online access to relevant data and analysis tools to improve public consultation on, and participation in, spatial decisions. This empowers communities by making the decision process more democratic and open. The third implementation, MC-GIS, was built as a demonstrator for site-selection problems (Malczewski, 1999a: 327). Finally, VegMan aimed at raising awareness, improving information access, enhancing detailed knowledge and encouraging the commitment of land managers and the wider community to sustainable native vegetation management.

Two further objectives were behind the development of OSDM (Carver and Peckham, 1999): 1) to gain insights into how users perceive spatial decision problems; and 2) to determine the manner in which individuals' characteristics may influence the decision made. Although no real participatory event has yet been conducted, Evans *et al.* (2004) attempted an answer (to these and other questions) by examining the OSDM usage of a pilot group of 167 individuals. The overall conclusion was that users tend to make informed and well-reasoned decisions when they have the opportunity to learn about issues and experiment with their choices.

II.3.4. SDSSs and learning

The first investigation into the benefits of using SDSSs at a personal (individual user) level was conducted by Crossland *et al.* (1995). Their study found evidence that using an SDSS contributes positively to the DM performance since it reduces the decision time and increases the accuracy in resolving a spatial-referenced decision task.

Mennecke *et al.* (2000), extending previous research, considered both inexperienced and experienced DMs. They concluded that SDSSs increase the efficiency of professionals in tackling spatial problems and significantly improve the performance of less experienced DMs, those with lower levels of knowledge and problem-solving skills.

These studies make clear that SDSSs improve decision-making, which implies that learning takes place. However, it should be noted that these studies emphasise the SDSSs's capabilities for efficient presentation of information (through interactive, colour graphical displays) and somewhat overlook the decision aid techniques that are (or may be) embedded in it.

De Marchi *et al.* (2000) and Holz *et al.* (2006) explicitly acknowledge that MCDM techniques, when used in an interactive environment, have learning-enhancing capabilities. Given that SDSSs have been conceived as flexible, interactive environments (*cf.* sections II.3.3.1 and II.3.3.2), where their model base includes MCDM techniques (*cf.* sections II.3.2.2 and II.3.3.2) it can be concluded that SDSSs are capable of stimulating and facilitating learning.

In particular, SDSSs can be argued to support adequately the individual component of learning (*cf.* section II.2.3). This is because SDSSs provide laboratory-like environments where the DM (user) can perceive the problem, explore the decision-making situation (meanings, alternatives, implications) and crystallise their own preferences (values and interests) regarding likely consequences, which the system should be able to predict.

II.3.5. Summary

Psychologists and cognitive scientists have claimed evidence for bias and errors in human reasoning and intuitive judgements. Decision analysis techniques and interactive decision support systems have been developed to improve decision-making.

This section introduced the concept of decision support and the widely used MCDM methodology. The most significant qualities of this methodology are that it (1) permits explicit consideration of the multiple facets of the decision problem; and (2) enables the conciliation of various and competing objectives for its resolution. However, MCDM requires the DM fully to articulate their objectives and values, which often are not obvious in complex spatial problems. To assist decision-making in such problems, SDSSs have been proposed. These are flexible problem-solving environments wherein the DM can investigate the problem, explore alternative outcomes and crystallise their own preferences and values. Originally designed for a single user, these systems rapidly were extended to support collaborative decision-making. This evolution resulted in a major step forward in broadening public access to decision-making with web-based implementations enabling the public to participate in spatial decision-making.

The section concludes with the contention that, as a result of their characteristics, SDSSs constitute a learning-enhancing framework, particularly for the individual component of learning.

II.4. Communication support in spatial planning

Since the late 1980s, the theoretical discourse in urban planning has been dominated by the 'communicative turn' (Allmendinger and Tewdwr-Jones, 2002). This framework requires planning to be performed through interactive, discursive and consensus-building practices; it appeared in response to the perceived failure of the public government, embedded in representative democracy, to deliver social justice and environmental sustainability. Over the past 20 years, various names have been used to describe the communicative turn: 'planning through debate' (Healey, 1992), 'communicative planning' (Healey, 1993), 'argumentative planning' (Fischer and Forester, 1993), 'collaborative planning' (Healey, 1997) and 'deliberative planning' (Forester, 1999).

This section focuses on computer-based systems that support communication processes, with an emphasis on the spatial planning context. First, the motivation behind these systems is presented. Second, two broad classes of systems are distinguished based on the complexity of their underlying argumentation model. Third, implementations of map-centred communication support systems are reviewed to depict the state-of-the-art in this field. Fourth, they are discussed in light of Kelly's PCT. The section concludes with a summary of the information presented.

II.4.1. Motivation for communication support tools

Communication support in the present context means structuring, organising and documenting multi-party debates. Three fundamental reasons motivate the development of communication support tools: knowledge sharing, conflict resolution and deliberation and decision-making support.

Knowledge sharing has different impacts depending on whether it takes place in the present or in the future. In the present, knowledge sharing allows stakeholders to gain information on how other stakeholders view the problem, what issues need to be looked at in particular, and which of the others' views deserve careful attention. In the future, knowledge represented as part of a decision process may be useful to support similar decisions and/or serve as a basis for learning and justification. For instance, it can alert stakeholders to possible errors, make evident faults in the procedure or be an example of a procedure to apply or improve.

Tweed (1998) said that examining the rationality behind other parties' claims triggers critical thought. In this sense, communication support tools assist stakeholders to construct arguments and counter-arguments and may even impel them to participate in the decision-making process and thereby enrich collective judgement, either by adding new arguments or elaborating on or challenging existing ones.

Individuals contributing to a decision problem typically present a strategy that fulfils their goals. Inevitably conflicts of interest arise. Communication support tools help to reveal vested interests, values, beliefs and rationales behind stakeholders' positions, and consequently serve as a basis for promoting mutual understanding and facilitating conflict resolution and consensus building (Gottsegen, 1998; Horita, 2000b; Karacapilidis *et al.*, 1997).

The third intention behind the development of communication support systems is to help deliberation and decision-making. The idea is that, if knowledge and argumentation are well-structured and organised, reasoning mechanisms and other types of services (e.g. to ensure consistency amongst the plausibility of related claims) can be embedded into these systems to support decision-making (see, for example, work by Lee (1990) and Karacapilidis and Papadias (2001)).

II.4.2. Two broad types of communication support systems

Communication support systems can be distinguished based on the underlying model of structuring and organising information (i.e. debate contributions). A broad division can be made between systems that follow a relatively simple model and those that follow a specialised model. Newsgroups and online discussion forums[3] follow a simple question/answer model, where single contributions are either of type 'question' or of type 'answer'. A question starts a new thread of discussion and an answer replies to a question or adds to a previous answer. The simplicity of this model turns communication support systems into relatively easy-to-use tools even for inexperienced users.

[3] The main difference between a newsgroup and an online discussion forum is that additional software, a newsreader, is usually required to read a newsgroup.

Argumentation systems (AS) follow a specialised model. These systems draw explicitly upon dialectical theories of argumentation, so their underlying argumentation model interlocks argumentation elements of nonambiguous type (e.g. issue, position, claim and rebuttal). Various argumentation structures have been developed to represent argumentation material. Tweed (1998) states that the most used structures in AS are the Issue-based Information System (IBIS) scheme by Kunz and Rittel (1970) and Toulmin-based logic (TBL), proposed by the philosopher Stephen Toulmin (1958). Figure II.4 represents the argumentation structures subjacent to IBIS and TBL.

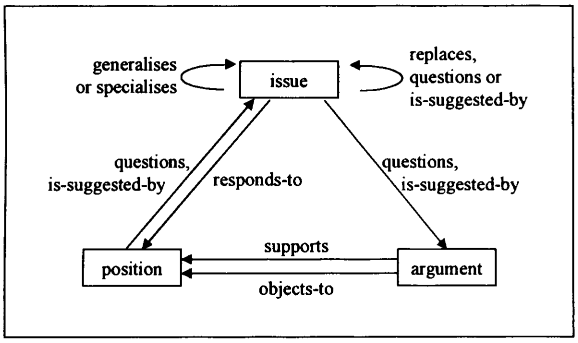


Figure II.4a – Relationship between IBIS elements (after Conklin and Begeman, 1988).

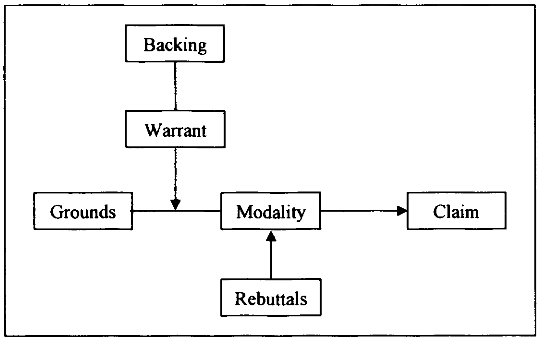


Figure II.4b – Relationship between TBL elements (according to Tweed, 1998).

Figure II.4 – IBIS's and TBL's structure for representing argumentation.

IBIS is well suited to depicting the discussion in which individual arguments take place. A computer system that implements IBIS is gIBIS (graphical IBIS) (Conklin and Begeman, 1988). It consists of a hyperlink system and was designed to capture early design deliberations. gIBIS was originally developed on Sun workstations and later implemented for the Microsoft Windows operating system, known as QuestMap™. It was subsequently improved and today appears as Compendium, "an open source Java hypermedia IBIS mapping tool" (Buckingham Shum *et al.*, 2005: 1). Two other computer systems that implement formal variants of IBIS are Zeno (Gordon and Karacapilidis, 1997; Karacapilidis *et al.*, 1997) and Hermes (Karacapilidis and Papadias, 2001). Both are Internet-based mediation systems, with the latter being an extension of the former.

In contrast, TBL is concerned with detailing the reasoning supporting an argument. An AS that implements a modified TBL structure is Synview (Lowe, 1985). Synview captures debate about scientific arguments. IBIS and TBL are not in direct competition; rather, they are complementary (Tweed, 1998). PLINTH (Tweed, 1994) and CrossDoc (Tweed, 1997) are systems developed to exploit this complementarity: their underlying argumentation model is a hybrid structure combining elements of IBIS and TBL. The first was developed to assist the authoring of regulatory codes and standards for buildings, and the second to support discussion on environmental impact assessment and planning applications.

AS have important advantages over systems like Usenet newsgroups or Internet forums. Their 'rigid' structure prevents discussions from going 'off-topic' and repeating arguments. In addition, structured and well-organised debate contributions facilitate grasping a debate's status. However, two aspects hinder their widespread use. First, before they can benefit from these rather complex tools, users must learn how they work. Second, because recognising arguments in a debate and separating them into components is not a trivial task, a skilled human mediator is often needed. Horita (2000a) reports that participants in a debate were unable to structure it adequately without such assistance. In response, the Autonomous Intelligent Systems (AIS) group, at the Fraunhofer Institute, re-implemented Zeno as Dito (AIS, 2001). Dito implements a looser argumentation model to provide flexibility and functionality. Dito can be seen as a compromise solution between easy-to-use, loosely-structured newsgroups and online discussion forums on one side, and complex argumentative systems on the other side.

II.4.3. Map-centred communication support tools

Participants in spatial planning discussions typically express concerns and comments by pointing to places on a map. For example, an argument contesting a new wind turbine very likely refers to its location and its geographical relation to other objects, such as dwellings or conservation areas. Some computational implementations referred to in previous sections enable users to attach images to their messages and format them using HTML (e.g. Internet forums and Zeno/Dito). Although this enables the author to make their point clearly, if other authors (stakeholders) want to refer to that image, they can only do it indirectly, via the original message.

The question of how conceptually to link written contributions to map locations or geographic features has interested various researchers. Gottsegen (1998) expanded the TBL argumentation model to include explicit consideration of geographic concepts. His purpose was to reveal differences in conceptions of regions and boundaries and use this information for conflict resolution. Nevertheless, no computational system currently implements this model.

One of the first computer-based systems to link discussion contributions and maps was developed within the scope of the European Commission funded project GeoMed (Geographical Mediation): the Internet-based mediation system Zeno was extended to provide access to geographical information resources (Gordon *et al.*, 1997). Uniform resource locators (URL) enabled users to request any document available in the GeoMed server, including maps. Each time a map URL was requested, a map viewer (Java applets) was loaded in the client browser and enabled the user to manipulate the map and query the server database (Karacapilidis *et al.*, 1997; Rinner, 1998).

In the context of the same project, Rinner (1998) proposed a different approach: integrate Zeno with the interactive map visualisation and exploration tool Descartes. In the process, he developed the concept of an argumentation map ('argumap') (Rinner 1999; 2001). Argumaps treat discussion contributions as individual objects, with well-defined relations amongst them, and link them to individual map elements. The linkage is established via an object-orientated model implemented in a database. Rinner has since updated the originally proposed object-orientated model (2005).

Using Rinner's conceptual model, Keßler (2004) developed a proof-of-concept system that combines a thread-based forum, comparable to a Usenet newsgroup, with a map display. This prototype is web-based and designed for non-specialist users. Users can browse the forum and the map separately. In the forum, users can read individual messages, respond to messages or create new discussion threads. The map is manipulable: users can change the current extent (e.g. zoom in and out and pan the map), select spatial objects and create their own graphical objects to add them as references to their discussion contributions. In addition, the prototype supports querying and analysing the geo-referenced debate. For example, when a user selects a discussion contribution in the forum, all referenced objects are highlighted on the map. Similarly, selecting an object on the map highlights all associated contributions in the forum. Users can also search the forum by keyword and identify potential areas of conflict, i.e. those map objects with the greatest number of written comments. Assessing the usability of the prototype using a quasi-naturalistic case study, Sidlar and Rinner (2007) concluded that participants were generally satisfied with the tools (high usability) but provided specific suggestions for improving its functionality and friendliness.

The integration of Zeno (which has become Dito) with Descartes (which has become CommonGIS) continued within the German Fraunhofer Institute's AIS as a platform for 'spatial discourse'. Voss *et al.* (2004) report on the integrative approach followed (a combination of evolutionary prototyping with participatory research) and propose solutions to identified requirements. The implementation of these solutions will yield the third generation of this integrated system.

A different 'spatial discourse' e-participation platform is described by Stefani Roeder in the IntelCities (Intelligent Cities) project report (Lahti *et al.*, 2006). This system integrates forum software, Dito, with an open source web map server, deegree (deegree.org, 2007), to offer a bi-directional link between the forum and a GIS-based map. A role-play experiment was designed to evaluate the system and investigate requirements for further development. The author concludes that the system facilitates "more precise, informed, focused and transparent" (Lahti *et al.*, 2006: 57) discussion than online discussions without the georeferencing feature.

Tang (2006) and Tang *et al.* (2005) describe a conceptually similar prototype. It is called GIS-enabled Online Discussion Forum (GeoDF) and integrates an online discussion forum, based on the open source bulletin board software phpBB, with ESRI's web GIS publisher, ArcIMS. GeoDF's functionalities are very similar to Keβler's argumap but include two novelties: 1) users can consult electronic documents (e.g. PDF files or video clips) made available through the user interface; and 2) a function informs participants about possible spatially-related issues discussed under a different topic. A major difference between the prototypes is the technology involved. While Keβler uses Java Applets that require a Java-enabled browser (otherwise, a Java-enabling plug-in must be installed), Tang's prototype, like the one described by Roeder, does not impose such a requirement.

Another implementation that enables map-referenced communication is CRANES (Coordinator for Rational Arguments through Nested Substantiation). Combining an AS with a GIS, CRANES is designed to structure conflicts with their geographical, strategic and argumentative dimensions (Horita, 2000b). The author suggests that a GIS specialist might be required to guide users in complex spatial analysis and queries enabled by the system. Horita (2000a) describes an experiment in which five participants completed a role-playing activity; he observed that these participants consistently failed to code their argumentation in a manner consistent with the argumentation model underlying the system. This suggests that CRANES is not suitable for non-specialist users. Unfortunately, the author does not make clear how he implemented the link between argumentation contributions and map entities.

Other implementations have also made possible geo-referenced contributions to support public participation in spatial planning. Al-Kodmany (1999b) describes Distant Participation for Pilsen Planning; citizens of the Pilsen neighbourhood, in Chicago, can select a cell on a transparent grid overlaying a map and state their reasons for liking or disliking this area of the community. In a subsequent stage, contributions referring to the same cell were grouped and, by clicking on a cell, citizens could read others' comments on that area. Virtual Slaithwaite (Kingston *et al.* 2000) offers similar functionalities. Instead of selecting a grid cell, however, citizens select a cartographic entity from a map (e.g. building, open space, river or canal) and associate comments with it. Virtual Slaithwaite was a project run in parallel with a Planning for Real® initiative (Gibson, 1998) as an ideal opportunity to compare traditional methods of public participation in environmental decision-making with web-based techniques. Ramasubramanian and Quinn (2004) describe a more sophisticated application in which online sketch tools enable citizens to select an area on a map by drawing a line, a point or a rectangle shape and attach comments to them. These comments are saved in a database and previously entered ones are available for consultation. However, while well suited to collecting citizens' views, these implementations provide less communication support than those earlier described – a consequence of not providing a forum-like environment that encourages and facilitates social interaction.

II.4.4. Argumentation maps (AMs) and learning

When analysed from the perspective of Kelly's PCT, map-centred argumentation systems, and AMs in particular, can be argued to stimulate the social component of learning (*cf.* section II.2.3). Indeed, by exposing the rationale behind a claim or position, they help individuals to construe the construction system of the claim's author and, where it is perceived to be useful, to engage in full learning (experience) cycles. Furthermore, since the rationale behind a claim may reveal the values and beliefs of the author, or even their goal and interests, it may prompt an individual to re-evaluate their own values and goals – which also implies undergoing (a) learning cycle(s).

Full learning cycles may have an impact upon one's personal construct system (*cf.* sociality corollary). As a consequence, two (or more) individuals engaged in a social role (i.e. socially interacting) may end up moving their positions closer to each other. Hence, besides fostering learning, AMs can facilitate the resolution of disagreements and consensus building – a primary motivation behind the development of these tools (*cf.* section II.4.1).

II.4.5. Summary

Knowledge sharing, conflict resolution and better decision-making have motivated the development of computer systems to support the communication process. These systems can be grouped into two broad classes: easy-to-use tools, such as Usenet newsgroups and Internet forums, and more specialised tools, such as gIBIS and CRANES, that implement a stricter argumentation structure.

As participants in spatial planning typically refer verbally to geographic objects (e.g. buildings or routes), communication support systems have been integrated with digital cartographic data (map or plan) to support more concrete and demonstrative discussions. A review of the most recent developments in this arena is provided. Finally, it was argued that these systems are capable of tackling the social component of learning: by disclosing the rational behind the claims, conflicts of interest are exposed and these may lead to reconstruing.

II.5. A learning-enhancing framework for participating in spatial planning

This section pulls together the three bodies of literature reviewed: George Kelly's PCT, SDSSs as instruments of decision support in spatial planning, and AMs as communication support tools in spatial planning.

Kelly's PCT informs us that individuals learn by revising constructs (i.e. reconstruing) after recognising incongruence between a construct and new evidence (*cf.* section II.2.3). PCT also suggests that drivers for reconstruing can be found either by introspection (i.e. making sense of experiences with the real world) or through social interaction (exchange of ideas, interests and understandings). These were, respectively, called the individual and the social components of learning.

SDSSs (and MC-SDSSs as a particular type) are designed as flexible and interactive environments wherein the DM can explore spatial decision problems, assess the likely consequences of alternative solutions and crystallise preferences with regard to decision-making (*cf.* section II.3.3). It is suggested that they facilitate the individual component of learning.

AMs are developed to support argumentation processes in spatial planning (*cf.* section II.4.3). They enable individuals to clarify the foundations of, and the values inherent to, their position and access other peoples' rationales. Because different ways of thinking may trigger reconstruing, it was argued that AMs promote the social component of learning.

Hence, PCT provides a theoretical framework that justifies cohesively integrating an SDSS and an AM: while the SDSS facilitates the individual component of learning, the AM stimulates the social component of learning. The hypothesis is that, besides tackling the two components of learning, synergies generated by an integrated system will foster a learning-enhancing framework for stakeholders (and more generally any citizen). Moreover, this framework enables stakeholders to collaborate with others and make informed contributions to spatial planning.

Figure II.5 shows a particularisation of this conceptual framework. In addition to the SDSS and the AM, it includes an information area. This area makes available objective and factual information on the decision problem and facilitates access to further information: relevant and easily accessible information on a problem is a first basic step in rational decision-making (Geldermann and Rentz, 2003) and may lead to reconstruing as much as information shared by other individuals.

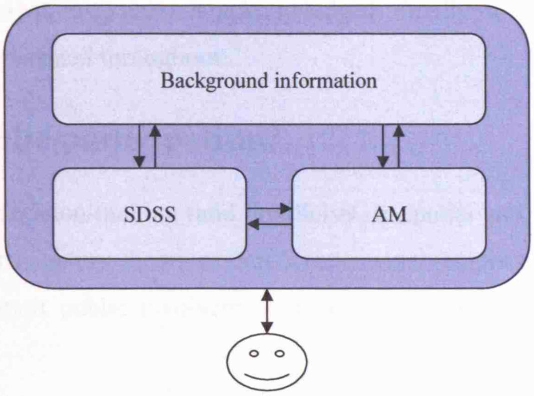


Figure II.5 – The proposed learning-enhancing framework to participate in spatial planning.

A system implementing this conceptual framework would arguably benefit laypeople and experts alike. By reconstruing, laypeople may come to understand the complexities underlying planning decision-making and even subsume an expert's construction system for the problem. At this point, they are able to play a role in a social process involving the experts (sociality corollary) and, for instance, challenge the drives behind a specific plan or propose an alternative solution.

For experts, such a system provides an opportunity to engage in the experience of subsuming a layperson's construction system. The diversity of such construction systems (individuality corollary) could prove an untapped reservoir of potential creativity that experts could harness to support their activities. In particular, planners (a type of expert) could use this experience to refine their proposals, thereby minimising divergence between the proposals and potential users' construction systems. As a result, laypeople's construction systems would be an integral element of the design process and participation in spatial planning would assume the sense *being* given by Stringer (1977). According to the author, this sense entails people being part of the designing process, which happen when they actually carry out the design – an unusual situation – or when their construct systems are an integral feature of the design process.

II.6. Public participation in spatial and environmental planning

As public participation in spatial and environmental planning is the application context for this research, the following sections briefly review fundamental aspects of public participation that offer support for this choice. In particular, sound reasons for public involvement in spatial and environmental decision-making are recognised, international agreements that encourage this involvement are pointed out, different levels of participation are identified and a move towards web-based public participation systems is acknowledged. Finally, a summary recapitulates the most important points presented throughout.

II.6.1. Why public participation?

Public participation in decision-making (and, implicitly, in spatial and environmental planning) finds its roots in the participatory theory of democracy, which emphasises "rule by the public". Various arguments support public involvement in decision-making. Fiorino (1990) identifies three:

- *normative* argument: technocratic orientation is incompatible with democratic ideals;
- *substantive* argument: lay judgements are as sound or more so than those of experts; and
- *instrumental* argument: effective lay participation in decision-making leads to better and more legitimate results.

Mitcham (1997) elaborates the *normative* argument, detailing it in eight arguments:

- *Techno-social realism*: experts cannot escape the influence of biased social interests, which affect their input to decision-making; public participation makes it possible to turn influence into open and articulated discourse and enlarge the range of interests engaged in the decision-making;
- *Public demand*: individuals and social groups increasingly demand a direct role in government;
- *Expert psychology*: experts inevitably tend to promote their own self-interests or values, instead of human welfare;
- *Consequences*: those affected by technical decisions should have some say over what affects them;
- *Moral autonomy*: as moral agents, human beings find their morals abridged when decisions that affect them are made by others without consultation (closely related to the previous argument);
- *Pragmatism*: due to greater pluralism of perspectives in the decision-making process, public participation leads to better outcomes;
- *Educational enlightenment*: only through active engagement and participation do individuals become more intelligent and aware of social reality; and

- *Post-modern cultural realism*: only participatory, democratic consensus is compatible with the values of tolerance, diversity and "public ethical minimalism" to which post-modern societies aspire.

In the context of disaster management, Hilhorst *et al.* (2002) articulate fundamentally the same reasons to support public participation in decision-making and add two others:

- it is a vehicle of empowerment: through participation vulnerable groups in society can be emancipated to speak up and be heard; and
- it is cost effective: by tempering institutional optimism in early stages of the process, costs incurred in irrelevant or unaccepted interventions are reduced.

II.6.2. International agreements of public participation

The soundness of the reasons for public participation in decision-making has impelled several international organisations to promote the involvement of citizens and stakeholders in environmental issues. The Rio Declaration on Environment and Development (UNEP, 1992), a document produced at the 1992 United Nations Earth Summit in Rio de Janeiro, asserts the crucial role of public participation in achieving sustainable development:

> "(...) At the national level, each individual shall have appropriate access to information concerning the environment (...) and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. (...)." (Principle 10)

This principle is elaborated further by the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (UNECE, 1998), known as Aarhus Convention, which provides for:

- the right of everyone to receive environmental information that is held by public authorities;
- the right to participate in environmental decision-making; and
- the right to review procedures to challenge public decisions that have been made without respecting the two aforementioned rights or environmental law in general.

On the European plan, the European Commission (EC) also fosters public participation. In 2003, two Directives were adopted to align Community legislation with the requirements of the Aarhus Convention: Directive 2003/4/EC on public access to environmental information (first "pillar" of Aarhus Convention); and Directive 2003/35/EC providing for public participation in the drawing up of certain plans and programmes relating to the environment (second "pillar").

European Union (EU) Member States were required to implement these Directives into national law by 25 June 2005.

II.6.3. Levels of public participation

There exist multiple degrees of participation. Writing about citizen involvement in planning processes in the United States, in 1969, Sherry Arnstein describes a *ladder of citizen participation* with eight steps: manipulation, therapy, information, consultation, placation, partnership, power delegation and citizen control (Arnstein, 1969). Ever since, other authors have proposed similar analogies. Wiedemann and Femers (1993) propose a six-step ladder of public participation based on the rights provided to citizens: public right to know; informing the public; public right to object; public participation in defining interests, actors and determining the agenda; public participation in accessing risks and recommending solutions; public participation in the final decision. Nobre (1999) establishes four main degrees of community participation: to inform, to consult, to discuss and to share (Laurini, 2001). Figure II.6 depicts the public participation spectrum developed by the International Association for Public Participation (IAP2). Moving up the ladder corresponds to increasing degrees of participatory governance.

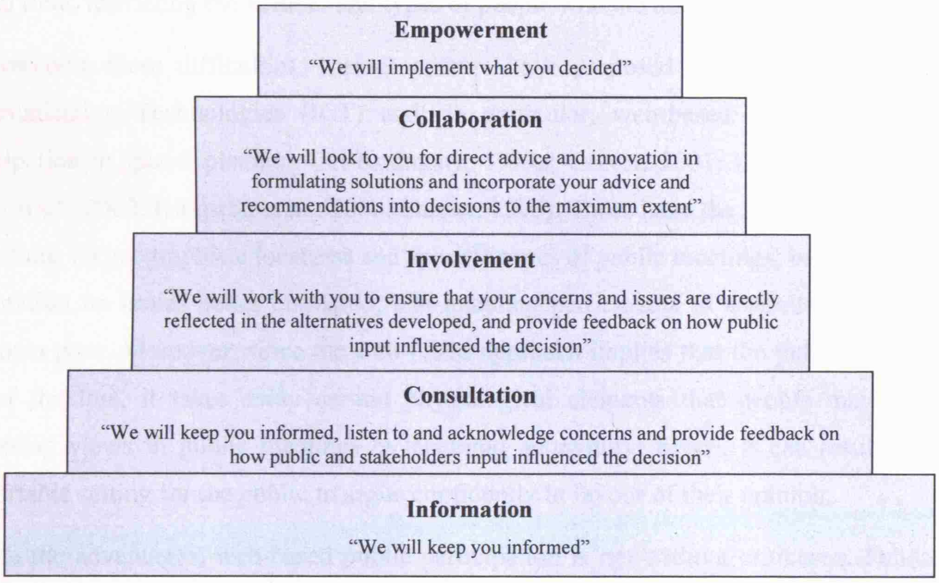


Figure II.6 – Levels of participation impact and what the decision-maker promises to the public and stakeholders (adapted from IAP2, 2007).

The levels of participation are associated with directions of information flow between the public (stakeholders) and the DM. At the lowest rung, only a one-way flow of information occurs, typically from the DM to the public (e.g. fact sheets or websites). Upper levels of the pyramid generally involve a two-way information flow (e.g. focus group, public meetings, workshops, citizen juries).

The top rungs in the pyramid have traditionally been closed to the public (Carver *et al.*, 1998). Today they are seen as desirable and should be opened up in the planning process (*cf.* section II.6.2). Methodologically, this creates new challenges as discussed in the following section.

II.6.4. Participatory methods: towards web-based participation

Traditional methods of public participation in the planning system range from neighbour notifications, exhibitions, public meetings and public enquiries through to high court hearings (Thomas, 1995). Over recent years, these methods have been criticised by many (e.g. Healey, 1998). In particular, council planning meetings have several characteristics that discourage participation. As Kingston *et al.* (2000) describe, they often sustain a tone of "them and us", with the authoritative DM holding all the knowledge, expertise and information and, more often than not, positioned on a platform with the general public down below in a less favourable physical and psychological position; they can be dominated by a vocal minority (activists); and often the whole process involves highly technical and legal "jargon" that is barely understandable by laypersons. Furthermore, council meetings are held in a fixed location and at a fixed time, restricting the number and types of people who are able to attend.

To overcome these difficulties, various authors have proposed the use of Information and Communication Technologies (ICT) and, in particular, web-based approaches for public participation in spatial planning (Al-Kodmany, 1999a; Carver, 2001; Howard, 1999; Hudson-Smith *et al.*, 2002; Kingston *et al.*, 2000; Shiffer, 1995). These have the advantages of removing restrictions on geographical locations and specific times of public meetings; increasing access to information on issues being discussed; and enabling participants to assimilate information at their own pace. Moreover, since the web-based approach implies that the public is at the other end of the line, it takes away certain physiological elements that people may face when expressing views in public meetings by enabling anonymity; hence, it can result in a more comfortable setting for the public to argue confidently in favour of their opinion.

Despite the advantages, web-based public participation is not without criticisms. Fundamental concerns relate to access to the technology and individuals' skills in using it. The gap between individuals that benefit from the digital technology and those who do not is known as the "Digital Divide" (DigitalDivide.org, 2007). The problem is that, if ICT-based methods are used in exclusivity for public participation, it creates a risk that some social groups will be under-represented in policy formation processes – which is incompatible with the equality principles of democracy. Addressing this issue, defendants of this approach stress that ICT-based public participation systems should not replace current participatory practices; rather, ICT should be seen as a way to enhance participatory practices as it creates opportunities for more people to participate (Kingston *et al.*, 2000). Other issues related to the use of ICT for public participation in spatial planning are discussed in Kingston *et al.* (2000) and Kingston (2002).

Many Governments have followed this move towards web-based systems under the concept of *electronic government* (e-government). In the planning arena, this concept materialises as e-planning, which has as its fundamental goal, delivering more efficient and accessible planning information and services. Addressing the UK implementation of the e-planning agenda, Kingston (2002) points out that most Local Planning Authorities' (LPA) websites only offer the three bottom rungs of the Wiedemann and Femers's (1993) ladder of public participation: public right to know, inform the public and give the public the right to object (*cf.* section II.6.3). They do not allow the public to participate in defining interests, actors and the agenda; nor assessing the social and environmental risks of alternative proposals or recommend solutions; nor participate in actual decision-making process.

In contrast, the purpose of this research is to develop a system that enables public participation at the higher rungs of the participation ladder and, for that, the full the potential of the Internet as a two-way channel of communication will be exploited.

II.6.5. Public participation and learning-enhancing system

When members of the public express a willingness to participate in spatial decision-making processes, they are often ill-equipped to do so: they may not appreciate the full range of issues involved, the aspects that need consideration, or be aware of the implications of their own stated preferences. For instance, Densham (1990) has shown that individuals often express a desire to refine their stated preferences when confronted with outcomes developed from those preferences. Consequently, to develop an informed understanding of the problem, and thereby contribute knowledgeably to decision-making, members of the public typically need to participate in a learning process. Using different reasoning, Hamilton *et al.* (2001) stress exactly the same point.

An adequate public participation system should encourage and stimulate learning. Hence, public participation in spatial planning offers a meaningful and interesting context in which to apply and assess the framework proposed in section II.5. This framework is expected to facilitate and enhance learning.

II.6.6. Summary

There are various sound reasons for enabling and encouraging public participation in spatial and environmental planning. Whilst some are directly linked to our concept of democracy, which is the ultimate argument supporting public involvement in decision-making, others are more prosaic, such as participation leads to better results or contributes to making citizens more aware of their social and political environment. The soundness of these arguments has led various international organizations to foster public involvement in environmental decision-making (e.g. United Nations (UNECE, 1998) and EC).

Several degrees of participation are possible, ranging from the public simply being informed of what has been decided to the public assuming full control of decision-making. Throughout this thesis, public participation is understood to be a collaborative process between the public (including stakeholders) and DMs at the level that IAP2 (2007) defined Collaboration (*cf.* Figure II.6). This implies a two-way flow of information between the participants in the process.

Traditional public participation practices, that enable a two-way flow of information, have various drawbacks. For example, they require interested people to be physically present at a certain time and place and face an audience when expressing their views. Web-based public participation systems have been advanced as a complement to these practices, engaging those who would otherwise be left out of the planning process. This is the backdrop against which the research in this thesis will make a contribution. More explicitly, the remainder of the thesis is concerned with implementing the proposed learning-enhancing framework within a web-based environment, with the ultimate goal of assisting members of the public to develop properly informed contributions and, thus, effectively participating in the planning process.

II.7. Overview and conclusion

This chapter contains five main sections that address three objectives. Three sections (II.2, II.3 and II.4) are dedicated to the first objective: introducing and reviewing the three branches of literature that support this research work.

Section II.2 presents George Kelly's PCT which posits that individuals learn by making sense of their experiences with the real world and by interacting with other individuals. This suggests that a learning-enhancing framework should offer support to these two components (dimensions) of learning: the individual and the social.

Section II.3 introduces the concept of decision support and the widely used MCDM methodology for tackling spatial problems. Moreover, it expounds on what SDSSs are and how they have evolved. Finally, it argues that, since SDSSs provide a laboratory-like environment where users can explore decision problems by investigating alternative problem solutions and crystallising individual preferences, they facilitate the individual component of learning.

Section II.4 deals with communication support systems: it reveals the motivation behind the development of these systems; splits them into two categories based on the underlying argumentation model; and summarily describes implementations that combine one of these systems with a map (or a plan). The latter are known generically as AMs and arguably foster the social component of learning. Indeed, by disclosing the rationale behind claims they expose 'conflicts' which may trigger learning cycles.

Section II.5 brings together the three branches of literature reviewed and fulfils the second objective: introducing the theoretical contribution of this research. Based on Kelly's PCT and the complementarities between SDSSs and AMs, the integration of these two types of systems is proposed to create a fostering, learning-enhancing framework for participation in spatial planning. In fact, the proposed conceptual framework integrates an additional component, consisting of an information area that should provide objective and relevant information on the problem being discussed and access to further resources.

Finally section II.6 accomplishes the third objective: introducing the general context in which the proposed conceptual framework is going to be applied. Public participation provides a meaningful and relevant context because (1) public participation in spatial and environmental planning is being encouraged as a means to achieve sustainable development; and (2) individuals typically need to undergo a learning process to contribute effectively to decision-making. Furthermore, this chapter identifies a move towards web-based public participation methods as a way to make the planning process more inclusive. The implementation of the proposed conceptual framework follows this trend.

Before moving on, three remarks seem worthwhile:

- The focus of this thesis on developing a learning-enhancing framework for public participation is quite innovative. Indeed, developments in the field of public participation, specifically when ICT-based systems are involved, have been concerned with making available data and tools for spatial planning and decision-making and to support/facilitate communication amongst members of the public and planners/DMs; learning as a goal in itself has been neglected.

- The proposed integration of an SDSS and an AM addresses a void in the literature identified by Rinner (2006: 91):

  "..., combination of both approaches still have to be developed."

  with approaches referring respectively to MC-SDSSs and other CSCW environments, such as AMs. Despite the complementarities between SDSSs and AMs, from the learning point of view, as argued in this thesis, and from the spatial planning point of view, as contended in Simão *et al.* (accepted), the integration of these two types of system has only been addressed by Voss *et al.* (2002; 2004) and in the context of the Participatory GIS for Transportation (PGIST) research project led by Tim Nyerges (PGIST, 2007). Voss *et al.* integrate two in-house software systems, Zeno and CommonGIS, to produce an e-platform for 'spatial discourse'; this is aimed at supporting human-moderated collaboration in geographical problem resolution rather than public participation in spatial planning. A recent presentation by the PGIST team (Zhong *et al.*, 2007) makes clear that they are integrating features of the SDSS GeoChoicePerspectives with discursive and deliberative support tools to support public participation in transportation decision-making.

- The proposed theoretical framework constitutes an original application of Kelly's PCT to spatial planning. Previous applications of PCT to spatial planning have invariably used the RepGrid technique to elicit individual perceptions/cognitive constructs on physical environments, which then are used to inform planning activities.

The next chapter identifies the requirements that an implementation of the proposed conceptual framework should satisfy to facilitate the development of informed contributions by members of the public.

Chapter III

Towards implementing the proposed framework: system requirements

III.1. Introduction

The previous chapter introduced the proposed framework for a public participation system that seeks to improve learning. This chapter investigates the implied user-system interactions to define requirements for a prototype implementation. This chapter contains three other sections that respectively: present the conceptual framework from the perspective of participant in spatial planning tasks, called *use cases* in object-oriented terminology; outline requirements for the system derived from the use cases description - requirements are drawn at various levels, including functionality, user interface, workflow, system's integrity, computing platform and security; and recapitulates and highlights the most relevant aspects of the information presented.

III.2. System use cases

A use case is a specification of actions that a system can perform during interaction with a user, called an actor. Use cases help to specify functional requirements for a computer system (Jacobson *et al.*, 1992).

Use cases associated with the proposed conceptual web-based public participation system involve two actors: the participant in the planning process (i.e. the user of the system) and the analyst interested in examining the usage of the system and receiving users' feedback. Figure III.1 provides an overview of the general relationships between the actors and the system.

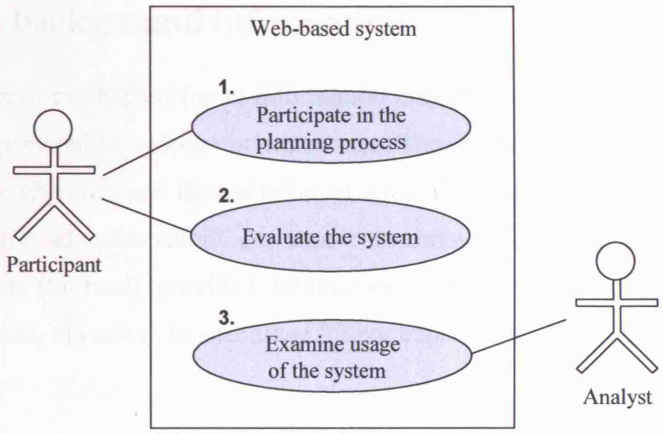


Figure III.1 – Overview of the relationships actors/system that the proposed participatory system must support.

To identify the functional requirements that the web-based system must support, the interactions depicted in Figure III.1 are detailed and associated to use cases in the next paragrahs. Use cases are introduced from the user's point of view, instead of from the system's point of view, to simplify exposition. This means that interactions enabled by the system actually correspond to supported use cases.

Using the conceptual framework described in the previous chapter, the interaction/use case 'Participate in the planning process' (identified with number 1 in Figure III.1) can be detailed as shown in Figure III.2.

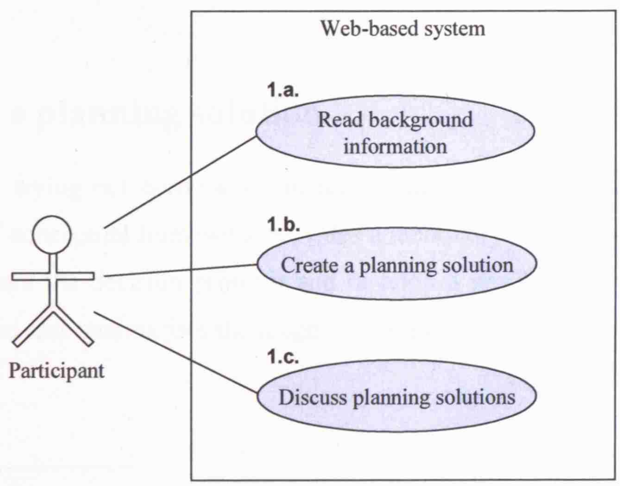


Figure III.2 – Detail of 'Participate in the planning process' use case.

Fundamentally, each module of the conceptual framework (i.e. information area; SDSS and AM - *cf.* Figure II.5) is associated with a specific use case: 'Read background information', 'Propose a planning solution' and 'Discuss planning solutions'. The following sections detail these use cases.

III.2.1. Read background information

As noted in the previous chapter, (new) information may lead individuals to reconstruing and, thus, enrich their personal knowledge or experience. The module 'Background information' is intended to provide objective and factual information on the spatial problem at hand (*cf.* section II.5). 'Read background information' use case encapsulates the usage of this module. This includes navigating (to read) provided information and accessing supplementary external information resources, via links[4], to encourage further exploration of the topic (Figure III.3).

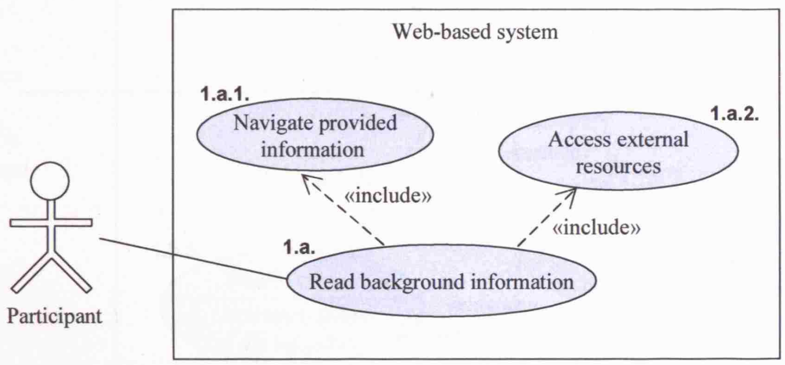


Figure III.3 – Detailed 'Read background information' use case.

The role of the system in this use case is to display information, which may be in textual, graphical, tabular or other format, and provide navigation mechanisms within and beyond the system.

III.2.2. Create a planning solution

Individuals learn by trying out constructs and reconstruing. As argued in section II.3.4, the SDSS module of the conceptual framework provides a laboratory-like environment wherein the participant can explore the decision problem and develop a problem solution. The 'Create a planning solution' use case summarises the usage of this module.

[4] The word "link" in used here instead of "reference" because a web-based implementation of the proposed framework is in mind (*cf.* section II.4).

Problem solutions reflect problem formulations. As people have different construct systems (individual corollary), it is unlikely that they all perceive the same reality (the decision problem) in a similar manner. Consequently, participants in the same planning decision-making situation could be resolving different problems. To minimise this risk, it was decided to pre-formulate and pre-structure the spatial decision problem before developing the SDSS module.

Since most spatial problems, if not all, require the consideration of multiple, often conflicting objectives (*cf.* section II.3.2.4), MCDM is considered an adequate and generic methodology to pre-formulate and pre-structure spatial problems. Based on this methodology, the 'Create a planning solution' use case can be detailed as shown in Figure III.4.

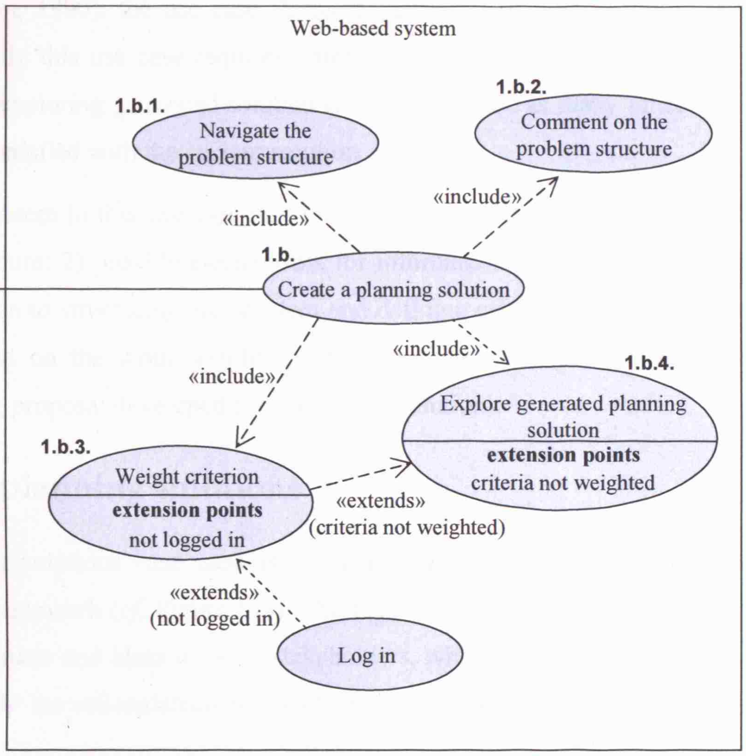


Figure III.4 – Detailed 'Create a planning solution' use case.

First and foremost, the participant needs to gain insight into how the problem has been formulated and structured, and how s/he can contribute to the planning process. This involves navigating information that can be provided in traditional formats (textual, graphical, tabular, etc.) or map-based. In the context of spatial decision-making, maps are useful for locating important features of the problem (e.g. the estate for which a redevelopment plan is in discussion), depicting alternative planning solutions and representing estimated consequences of alternative solutions.

The MCDM methodology implies that participants in the decision-making process should contribute to the problem formulation and structuring. Since it was decided to accomplish these steps in advance, the current formulation might not reflect the participant's perception of the problem. The use case 'Comment on the problem structure' (*cf.* Figure III.4) gives to the participants the opportunity to react to, and contribute to, problem formulation. For instance, they can point out aspects or evaluation criteria that they think have been disregarded (or need adjustment) in the current formulation.

Following the MCDM methodology, the DM needs to express the importance (i.e. weight) that s/he attaches to each evaluation criterion identified during problem structuring to generate a problem solution. The 'Weight criterion' use case captures this action. As DM often need to refine their stated preferences (i.e. entered weights for the criteria) after visualising/analysing its consequences (Densham, 1990), the use case 'Explore generated planning solution' supports these activities. Naturally this use case requires criteria to be previously weighted. The cycle (re)stating preferences-exploring generated solution can be completed as many times as needed, until the participant is satisfied with the current solution.

Thus, the role of the system in this use case is: 1) display information on the problem and the problem-solving procedure; 2) provide mechanisms for information navigation; 3) capture the participant's contribution to structuring the problem and defining criteria weights; 4) generate a planning solution based on the input weights; and 5) provide an iterative environment for revision of the planning proposal developed (i.e. generated solution).

III.2.3. Discuss planning solutions

The 'Discuss planning solutions' use case is associated with the AM that integrates the proposed conceptual framework (*cf.* Figure II.5). The idea behind this module is to expose the participant to the constructs and ideas of other stakeholders, which may trigger reconstruing or impel him/her to clarify the rationale/constructs behind their position on the problem and/or planning proposal.

Figure III.5 details the 'Discuss planning solutions' use case. The participant can inspect the current state of debate by navigating through submitted contributions and, beyond that, exploring the debate itself to find out, for example, whether it has been dominated by a group of people or to identify major areas of conflict. Moreover, the participant can actively participate in the debate by making contributions to the discussion.

To express their message effectively, the participant may like to associate spatial references with their contribution. For example, when making a point about a proposed wind turbine which s/he believes is going to disturb migrating birds, s/he can draw the birds' path on the map and select the wind turbine's location. By referring to both in their message, ambiguity and misunderstanding are minimised and the reader will comprehend the message more effectively.

Carver and Openshaw (1996) suggest that combining individually developed "idea maps" supports the identification of physically and socially robust solutions to siting problems. The resulting map, which can be called a "social planning solution", would not just serve to convey the public's feeling about a solution for the problem at hand, but also to expose conflict areas. Such a map constitutes a good basis for discussion. The 'Discuss planning solution' use case includes the inspection and exploration of a "social planning solution". Here, inspection corresponds to map (i.e. planning solution) navigation, while exploration involves information consultation and analysis, such as the number of people who agree and disagree with the currently displayed solution.

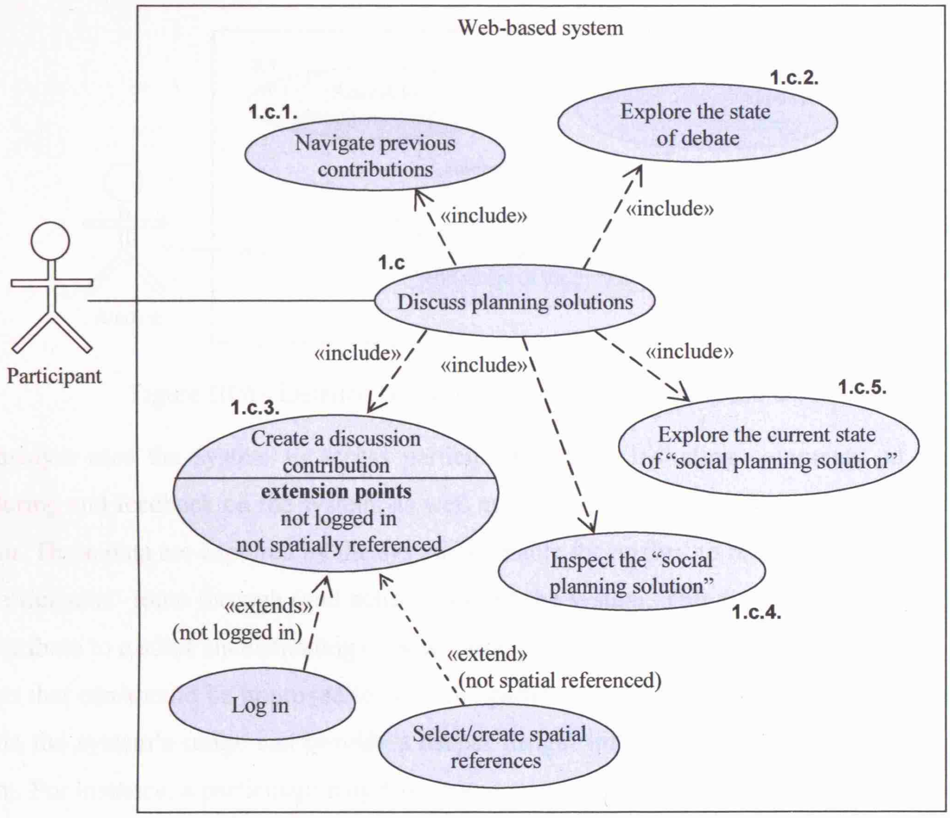


Figure III.5 – Detailed 'Discuss planning solutions' use case.

Hence, the role of the system in this use case is to: 1) display the discussion contributions and associated spatial references; 2) enable the participant to create a discussion contribution and associate it with spatial references; and 3) provide the means for the participant to navigate through and explore the debate as well as the "social planning solution".

III.2.4. Evaluate the system

The 'Evaluate the system' use case (*cf.* Figure III.1) involves the participant in answering a feedback questionnaire designed to assess the extent to which the proposed conceptual framework succeeds in providing a learning-enhancing framework. The system's role in this use case is to display the feedback questionnaire and store submitted responses.

III.2.5. Examine usage of the system

In contrast to previous use cases, 'Examine usage of the system' involves an analyst as an actor instead of the participant, Figure III.6.

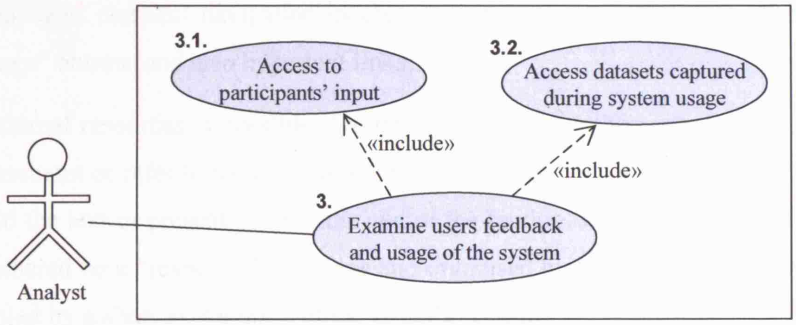


Figure III.6 - Detailed 'Examine usage of the system' use case

The analyst uses the system to access participants' input, including comments on problem structuring and feedback on the system, as well as data captured while the participants used the system. These data are captured by the system to enable the analyst to reconstitute, *a posteriori*, the participants' route through (and actions within) the system. This reconstitution is expected to contribute to a solid understanding of how participants use the system and help identify those aspects that can/should be improved to "induce" participants to perform as intended. Moreover, data on the system's usage can provide a deeper insight into the participants' appraisal of the system. For instance, a participant may have commented, incorrectly, that a certain aspect of the problem was not considered. The participant's record of using the system can shed light on this incongruence: he has not visited the part of the system where this aspect was explained and dealt with. Thus, the role of the system in this use case is to provide access to information collected and stored during the participants' usage of the system.

III.3. Requirements of the system

The following paragraphs identify requirements for the system to support the described use cases. Requirements are first identified for each module of the proposed conceptual framework, and then for the system as a whole.

III.3.1. Background information module

III.3.1.1. Functionalities

Reflecting the web-based character of the intended system, this module is envisaged as a set of webpages that address specific topics about a spatial problem. The functionalities required by this use case are:

- navigation within and between webpages: and
- access to external resources.

Within a webpage, navigation is typically possible through scrollbars and hypertext links. Between webpages, classical navigation mechanisms include navigation bar, "Previous Page" and "Next Page" buttons and also hypertext links.

Access to external resources is possible through hypertext links. Nevertheless, if the aim is to back up a statement or refer to a document for further explanation, it is recommended to embed resources into the text or present them at the end of the section. In a website, external resources should be gathered on a "resources" webpage and organised by topics. Ideally, each link should be accompanied by a short explanation of the target's content.

To facilitate users' familiarisation with the system, these conventional navigation and external resource access mechanisms should be implemented.

III.3.1.2. User interface

Specialists in web usability provide golden rules and hints on how to optimise the user's experience of a website (e.g. Flanders, 2007; Lynch and Horton, 2002; Nielsen, 2000; 2007). For the user interface they establish the fundamental requirements as simplicity, pleasance and uniform appearance. Furthermore, they advocate adherence to web design standards and conventions. This increases the website's intuitiveness and diminishes the risk of it being experienced other than as intended.

With regard to navigation, specialists recommend a consistent and predictable navigation bar. This gives users a sense of the website's organisation and makes workflow intuitive. Specialists also highlight the importance of linking to the website's homepage from every page, typically realised via the website/company's logo, and endorse the provision of a "breadcrumb trail" to give users location information and shortcut links to previous categories. Furthermore, they suggest using different colours for visited and unvisited links to minimise navigational confusion (e.g. unintentionally revisiting the same webpage).

In terms of information presentation, experts recommend designing the user interface to reflect key strategies that web users employ to assess a website's interest: skimming and scanning. Skimming is glancing quickly over webpage content to get a general idea of the information being presented; the focus goes to headings, illustrations and diagrams. Scanning is looking for keywords and phrases to see if the page covers information that they are looking for or are interested in. This suggests that topics covered in the website should be brought to the fore. Expressive headlines should capture the user's attention while sub-headings, that expand upon the "story" suggested by the main headings, draw the reader into the body text. Instead of long chunks of text, information should be presented in more visually appealing ways, such as bulleted text and diagrams. Emphasis (e.g. bold or italic formatting) should make keywords evident and keep the reader's attention. As web users are impatient readers, text should be written in a concise and inverted pyramid style, i.e. starting with the conclusion. Concrete examples and analogies are useful for communicating complex ideas.

Web users typically leave a website if they perceive the information to be inadequately subjective, distorted or not coming from a reputable source. Thus, objectivity and credibility are important. Controversial or surprising viewpoints/argumentation should be backed up by credible references and, here, links to external resources play an important role.

Outbound links can cause the visitor to leave the website. To minimise this possibility, external links can be opened in new pop up windows. This allows the visitor to surf the external website to their hearts content, and, when s/he is done and closes the window, the website is still up, waiting for her/him.

III.3.2. SDSS module

III.3.2.1. Functionalities

The use cases associated with this module require the system to:

- provide mechanisms to navigate information, both textual and map-based;
- elicit and store user input;
- handle an association between elicited input and the respective author (user);
- have an "engine" to generate a planning solution based on the user input and represent it on a map; and
- provide tools to facilitate investigating the generated solution.

Requirements identified for the module 'Background information' are still valid here for navigating textual information. For map-based information, the usual map navigation tools to zoom in and out, pan, and display full map extent should be provided; these enable the user to examine particular areas of interest.

Forms to collect user input should reflect the type of input sought. For instance, to receive comments on problem structuring, unstructured message forms are appropriate because they permit freedom in composing the input. In contrast, to acquire a criterion weight a structured form seems preferable. Ideally, whenever possible, validation rules should be associated with structured input forms to guarantee the integrity or validity of entered data. For example, a validation rule should be associated with each criterion weight input form to issue an alert if the participant enters a value greater than 100.

Input data needs to be stored in a structured way in a readily accessible warehouse that facilitates input revision and later access by the analyst. As input revision should only be possible by the pertinent author (user), the system must be able to create and maintain an association between the user and their respective input. This association is also important to enable a conjoint analysis of feedback on the system and path and actions of the user on it.

According to the MCDM methodology, the required "engine" should consist of a decision rule to compute a recommended course of action based on the user's stated preferences (i.e. criteria weights). Depending on the problem, displaying the generated solution on the map may involve highlighting (or drawing) the recommended course of action on the map, or colour-coding map features (alternative courses of action) based on the computed ranking/suitability for decision-making.

Finally, map navigation tools support only lightweight examination of the generated solution; more comprehensive examination requires additional functionalities. The problem at hand determines the relevant functionalities. Generically, the traditional "identity" tool may be an interesting feature: for a selected map feature it retrieves and returns to the user all associated alphanumeric information. If a building is selected, for example, returned information may include the number of floors, the number of residents and total area allocated to commercial use.

III.3.2.2. User interface

The SDSS module displays information on the problem, including the identified evaluation criteria. To keep the user interface simple, each evaluation criterion should be addressed on a different webpage. Moreover, fundamental information should be separate from details: while the former should be part of the main webpages, the latter should be easily accessible through hypertext links.

For the sake of intelligibility, data on the same topic should be presented together. This implies that, if spatial (map-based) information is relevant for the comprehension/apprehension of the topic, a map viewer should be hosted beside textual information. Similarly, if user input is sought on that aspect, input forms should be placed nearby. Thus, it is envisaged that webpages in the SDSS module will integrate textual information, a map viewer, forms to collect the participant' input and navigation tools.

Map navigation tools should be associated with the map viewer. Other tools typically associated with a map viewer are (1) a scale bar, (2) a table of contents (TOC) that enables the participant to control the visibility of thematic cartography layers, and (3) a map legend to aid interpretation. The last two can be integrated in the same user interface component by having a checkbox next to the symbol (colour) used to represent a layer on the map - a map layer is visible only when its checkbox is ticked. Another helpful feature is an overview map; this feature should depict the exact extent and location of the area displayed in the main map in the context of the whole study area.

Tooltips and labels should be used to provide context sensitive help. For instance, to elucidate the purpose of a tool and how to use it or to make clear the meaning of the map legend (e.g. by displaying "darker colours on the map represent higher altitude sites").

III.3.2.3. Workflow

The MCDM methodology underlying this module presupposes a logical enchaining of activities. The user (DM) should start by learning the structure of the problem, then inspect each evaluation criterion for decision-making and weight it and, finally, examine the recommend decision-making (*cf.* section III.2.2). An SDSS should, nonetheless, support a variety of decision research strategies (Densham, 1991). Thus, freedom should be given to the DM in carrying out these activities.

An adequate design for this module is to sequence activities according to the MCDM methodology but provide flexibility and freedom through the navigation bar. "Next page" and "Previous page" buttons guide the DM sequentially through the decision-making process, while the navigation bar should allow straight access to any phase of the process.

While developing a planning solution, the user may feel the need to (re)visit some material provided. Hypertext links should be planned to yield direct access to information likely to be consulted from a certain point and allow easy return to the departure point. The navigation bar allows more personal investigations.

It is anticipated that the DM will want to revise their criteria weights after examining the first planning solution. An easy way to achieve this should be contemplated in the workflow design. One attractive option is to provide a form for input revision and a button to generate a new planning solution right beside the map that portrays the generated solution.

III.3.3. AM module

III.3.3.1. Functionalities

Use cases associated with this module require the system to provide:

- mechanisms to inspect discussion contributions and explore the current state of debate;
- mechanisms to create new discussion contributions;
- interactive tools to select from the map and create spatial entities that can be referred to in the discussion contribution;
- the ability to handle an association between contributions and their respective "spatial contexts";
- capabilities to generate the "social planning solution" and display it on the map viewer; and
- functions to explore the current state of the "social planning solution".

From the organisational point of view, a core requirement is for the user to trace the evolution of discussion; the AM's underlying argumentation model ensures that this is so. As examined in section II.4.2, simpler, familiar argumentative models, such as the question/answer model, are preferable for laypeople. Nevertheless, organising the discussion contributions facilitates grasping the state of debate. A good compromise seems to be reached by Keβler (2004). He proposes that contributions are organised by topics/issues and classified using simple types (suggestion, question, argument for, argument against or neutral).

To inspect discussion contributions two mechanisms are relevant:

- to display the full text of the message (typically discussion contributions are presented in compressed form, with only the title visible); and
- to display the corresponding "spatial context", that is, the visible map configuration at the moment the contribution was submitted by its author (map extent, visible map layers and spatial entities referred to in the message). This ensures that the current user has in view everything that the author of the contributions refers to; otherwise, the understanding of the contribution could be compromised (e.g. if a spatial entity referred to in the message was outside the visible area).

The following functionalities are useful for exploring the current state of debate: 1) search discussion contributions by keyword; 2) select contributions based on attributes, such as author or submitted date; 3) highlight in the map viewer the spatial references of selected contributions; 4) highlight the contributions associated with selected spatial references; 5) show the number of contributions associated with selected spatial references, grouped by attribute (e.g. type of contribution); and 5) point out the hottest areas of discussion (i.e. the spatial references that have been referred to the most).

To explore the "social planning solution", a relevant functionality is to display the number of users that are in favour of, neutral towards and disapprove of it. This will enable an appreciation of the controversy associated with this "social" solution.

III.3.3.2. User interface

As discussion contributions consist of verbal and spatial parts, this module's user interface should host the discussion and the map viewer side-by-side. This would result in a much more user friendly solution than one that forces the participant constantly to switch between the discussion and the map viewer to gain an overview of the discussion. Ideally, the user interface should allow for dynamic adjustment of the size of both components, so the participant could increase the size of one component to focus on it (the size of the other component would adjust automatically).

The map viewer is the interface for visual perception of geo-referenced arguments and the mechanism by which users select or sketch spatial references to refer to in a contribution. To keep the distinction between spatial references associated with existing discussion contributions and the user's spatial references (either sketched or selected from the map), each should belong to different thematic layers and be displayed in different colours.

As in the SDSS module, tooltips should be used to provide information on interface elements and labels can be attached to map entities to help identify real world entities (e.g. a label "library" can be associated with the respective cartographic representation). Labels can also be used to provide information on the contribution(s) associated with spatial references: a label could display the number of discussion contributions that refer to a selected spatial reference and, if only one contribution does so, its title could be shown. Labels should become visible when the participant hovers the mouse pointer over map features for a certain period of time, such as one second.

To assist orientation, the spatial entity referred to by a label should be highlighted. Different colours can highlight entities in different thematic layers. The participant should be able to adjust the highlight colours to guarantee that s/he can differentiate highlighted features from others on the map.

III.3.3.3. Workflow

The AM module should support flexible workflows. To inspect discussion contributions, users should be able to either open messages in the discussion forum to access their content or use spatial references as a cartographic index to discussion contributions – that is, initiate navigation from the map. Moreover, users should be able to add contributions by first writing messages and then adding spatial references (i.e. departing from the discussion side) or by creating spatial references and then writing contributions (i.e. starting from the map side). More generally, it should be possible to edit both the contribution and its spatial references in no specific order until the contribution is submitted. Once submitted, editing should no longer be possible to preserve the consistency of the discussion structure. Otherwise, a discussion contribution with a reply could be deleted or edited and the reply no longer make sense.

III.3.4. The system as a whole

Despite the various modules, the system must be integral, a whole unit. A sense of unity can be created by:

- harmonising and cohesively integrating the user interfaces of the various modules - the participant must not perceive any transition between modules;
- enveloping all modules within a home and a final page, the former stating the purpose of the system and how the user can participate and the latter thanking them for contributions made; and
- offering a navigation bar that enables access to any module at any time.

The last aspect is very important because knowledge acquired in one module can be relevant to contributions provided in another module. For example, the participant may want to re(visit) information provided in the background information module when developing a planning proposal in the SDSS module. Furthermore, since interaction with other people may reflect back on one's construction system (as suggested by Kelly's PCT), a direct connection should exist between the AM and the SDSS modules to assist revision of one's planning proposal after learning from others or gaining perception of the collective judgement from the "social planning solution".

Finally, the use cases 'Evaluate the system' and 'Examine usage of the system' are important in fulfilling the goal of this research. These use cases require the system to:

- display a feedback questionnaire and store responses;
- capture data on the usage of the system and store it;

- handle an association between feedback and its author (the user) and between this and records of "tracking" data; and
- allow easy access to stored information.

III.3.5. Computing platform

To satisfy the web-based requirement, the system must implement a *client-server* architecture. Such an architecture separates a *client* from the *server* and is implemented over a computer network. The *client* accesses a remote service on another computer, the *server*, over the network. Communication over a network is possible through the Internet Protocol Suite, also called TCP/IP Protocol Suite after the two most important protocols in it: the Transmission Control Protocol (TCP) and the Internet Protocol (IP).

The terms *client* and *server* can also refer to hardware and software. The user's computer and the web browser s/he uses to send requests to a server are considered the *client*; the computers, the databases and the applications that provide responses to the client are considered the *server*.

Requirements for the system's server are: 1) capacity to process requests from the client and serve the reply; and 2) capability to store spatial and non-spatial data. A major requirement for the system's client is to run on major web browsers, such as Internet Explorer or Mozilla Firefox[5]. Ideally, it should also be resolution-independent, as various screen resolutions are in use, and not require the installation of any browser plug-in as users may not have the privileges to install software on their machines.

III.3.6. Security issues

Security is crucial for real world applications of the proposed system. To reduce the chances of hackers breaking into the server and altering webpages, the following are important: 1) use of passwords to restrict access; 2) keeping server software current with security patches and updates; 3) using *firewall* software to prevent access to the server except via specific ports; and 4) disabling unnecessary features to minimise vulnerability.

Requiring users to register and login to make a contribution may dissuade them from manipulating the debate and the "social planning solution", but no simple mechanism is effective in preventing this. Explicitly associating authors with their contributions enables other users to realise whether the discussion has been dominated by a single author or a small group

[5] According to w3school.com, at the end of the second trimester of 2007, users of these web browsers represented about ninety percent of the Internet community - about 60% use Internet Explorer and about 35% use Firefox. Similar data is provided in http://www.twospots.com/.

of authors. Such an approach also enables the system to recognise returning users and thus update the "social planning solution" when a participant revises a classification instead of considering it a new classification. Making authors responsible for their input also discourages the use of inappropriate vocabulary and aggressive behaviours.

III.4. Conclusion

This chapter formalises the conceptual framework proposed in Chapter II and identifies functional, user interface, workflow, computing and security requirements for a prototype implementation.

Relevant aspects are:

1) Since the intended prototype is for laypeople, its user interface should be developed following conventional designs. This will make the system both intuitive to use and consistent throughout, despite the various modules. The number of functions and options available should be kept to a minimum to avoid confusing users while tooltips and labels should be provided to assist usage and make the user interface more self-explanatory.

2) Workflow within the system should be flexible. Users should be able to develop their contribution as they deem appropriate. In particular, they should have the freedom to jump between different sections of the system as this can assist/encourage access to information and, hence, facilitate learning.

3) Nevertheless, inexperienced (web) users should be guided throughout the system to prevent them from abandoning it because they were not able to find their way around. This implicitly led to recommending a sequence through the three modules of the proposed conceptual framework. As figure III.2 suggests, the recommended path consists of: first, read and learn from problem-related information provided in the "Background information area"; second, develop a planning proposal in the SDSS; third, discuss proposals or problem-related issues in the AM. As social interaction may lead to reconstruing, it is desirable to establish a direct connection between the AM and the specific area of the SDSS where revision of individual planning proposals is possible.

4) Providing flexible navigation and a recommended path through the system is a response to a question raised initially: in which order should the SDSS and AM be arranged to foster learning? User feedback will possibly shed some light on this proposed arrangement. Moreover, the prescribed cross-module navigation menu, consistent user

interface throughout the system and direct connection between the AM and the SDSS mentioned in 3), constitute a first attempt to respond to the question "How to realise an effective linkage between the SDSS and AM in a way that is simultaneously seamless and puts into practice Kelly's cyclical conception of learning? Here, again, user feedback will be important in evaluating the effectiveness of the proposed solution.

Chapter IV

Wind farm siting as a case study

IV.1. Introduction

Implementing the proposed framework requires a case study. The siting of wind farms is considered to be an engaging and relevant spatial (and environmental) planning problem to be tackled within the proposed framework. In addition to these characteristics, two other aspects were important in selecting this case study. First, as a way to increase the acceptance for wind energy, there has been a call for public involvement in the wind farm planning process. Second, mostly due to unawareness but also due to overstatements circulated by some pressure groups (advocates and critics) and the media, there is scope for learning on the topic.

This chapter has four fundamental purposes. First, to introduce the topic of wind energy and justify the choice of case study. Second, to present the background of the selected case study: since the case study area is located in England, the UK wind energy framework is outlined, as well as the opportunities that the general public has to participate in wind farm planning. Third, to make clear the formulation of problem tackled within the proposed framework. Finally, to describe the case study area and explain how it has been identified. The chapter addresses each of these four goals in turn and concludes with a summary and discussion of the material presented.

IV.2. Wind energy overview

In many parts of the world, wind energy has already grown to be a mainstream energy source. This growth has been driven by a number of factors, of which the two most relevant are concerns about energy security and global climate change (Greenpeace and Global Wind Energy Council, 2006). Wind energy has come to the fore partly because it is one of the most environmentally benign electricity sources and partly because it is amongst the least costly renewable energy (Enviros Consulting Ltd, 2005; European Wind Energy Association (EWEA), 2005; Sustainable Development Commission, 2005).

The following sections provide an overview of wind energy development in the world and, more specifically, in the UK. Whilst an examination of the technology itself is beyond the scope of this research, the interested reader is referred to two valuable online resources: the Danish Wind Industry Association (DWEA) website and the Wind Energy Handbook by Burton *et al.* (2001).

IV.2.1. Wind energy worldwide

Wind power is established as an energy source in many countries around the world. At the end of 2006, the world's total installed wind power capacity was nearly 74 GW. During 2006, a total of 14.9 GW of new capacity was installed, representing a 25% cumulative growth. The previous year the installed capacity had been 11.3 GW (24% growth) and, in 2004, 8.3 GW (21% growth), as depicted in Figure IV.1.

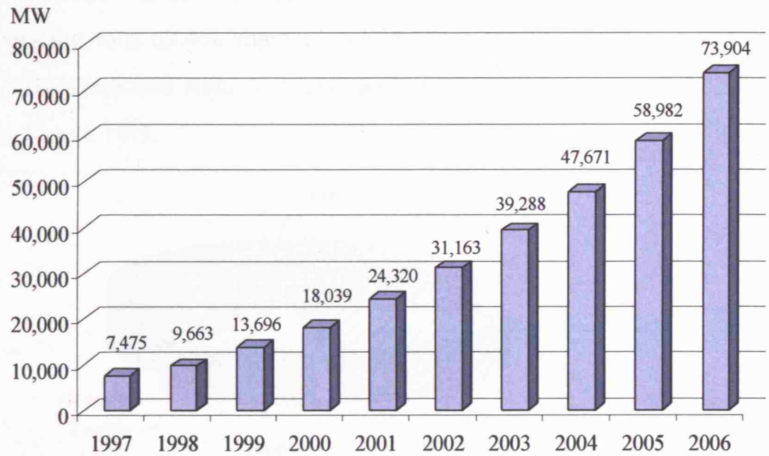


Figure IV.1 – Worldwide wind energy installed capacity as of 31st Dec. 2006 (WWEA, 2007).

The World Wind Energy Association (WWEA) expects this dynamic to continue in coming years and estimates that 90 GW of wind power will be installed by the end of 2007 with an overall operational capacity of 160 GW by 2010. This implies an average annual growth rate of more than 21% over the next four years.

Figure IV.2 shows the growth, during 2006, in installed capacity of the twelve leading markets. Five countries added more than 1GW: the United States of America (2.45 GW), Germany (2.19 GW), India (1.84 GW), Spain (1.59 GW) and China (1.14 GW).

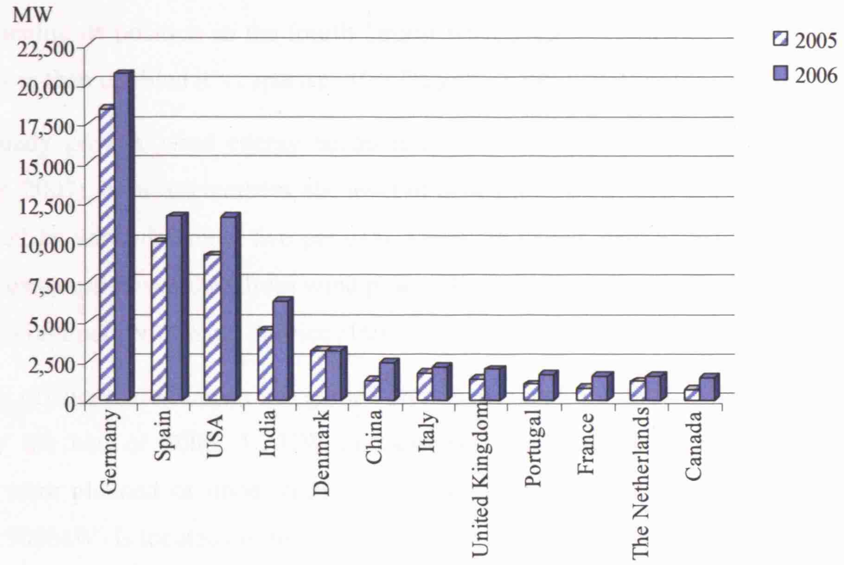


Figure IV.2 – Top 12 nations in wind capacity installed as of 31st Dec. 2006 (WWEA, 2007).

Germany remained the world's largest wind power generator with an installed capacity of around 20.6 GW at the end of 2006, followed by the US and Spain with installed capacities of 11.6 GW.

At the end of 2005, Europe was the leading continent with an installed wind energy capacity of 40.9 GW, corresponding to a 69.4% share of world capacity. The Americas followed in the ranking with a 17.0% share and Asia was next with an overall capacity of 7.02 GW (11.9% share), as shown in Figure IV.3.

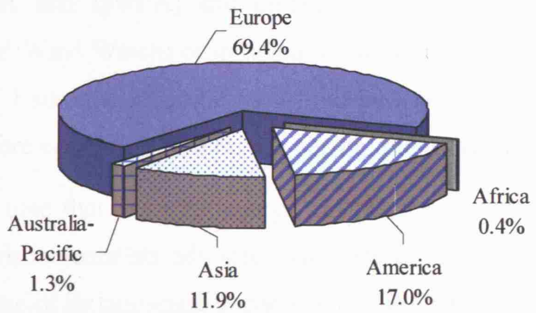


Figure IV.3 - Worldwide wind energy installation per continent as of 31st Dec. 2005 (WWEA, 2006).

At the end of 2006, Europe remained the most important market with an installed capacity of 48.5 GW (18.6% growth rate), 98.9% of which was within the European Union (EU)-25

(EWEA, 2006). According to Wind Service Holland (2007), generated wind power is enough to meet approximately 3.3% of the EU's electricity demand.

Asia is, nevertheless, the most dynamic world region in terms of wind energy development, with India and China the major drivers. During 2006, India increased its installed capacity by 41.5% strengthening its position as the fourth largest wind market worldwide (*cf.* Figure IV.2) while China more than doubled it's capacity (104.7% growth rate) (BP, 2007).

Despite the steady growth, wind energy accounts only for around 0.8% of global electricity generation (BP, 2007). In most countries, the level of penetration of wind energy (i.e. fraction of energy produced by wind) is below two per cent. Denmark excels with approximately 14% of its electricity consumption supplied from wind power; Germany and Portugal with nine per cent and Spain with eight per cent (Wind Service Holland, 2007).

In recent years, offshore wind power has gained prominence and will play an increasing role in the future. By the end of 2006, 1.3 GW of capacity were installed worldwide and many developments were planned or under construction. A significant percentage of this capacity (68% or about 900MW) is located around Europe, in the coastal waters of Denmark, Ireland, the Netherlands, Sweden and the United Kingdom (EWEA, 2007). This represents about one-point-eight per cent of the cumulative installed capacity of wind power.

IV.2.2. The debate around wind energy

Wind energy can be a controversial issue. A wealth of resources discusses the pros and cons of wind energy, including: books (e.g. Gipe, 1995); scientific papers addressing particular issues (e.g. Strachan and Lal, 2004; Warren *et al.*, 2005); reports and websites from Governmental departments and other agencies (e.g. Sustainable Development Commission, 2005 and Department of Trade and Industry (DTI) website); leaflets, fact sheets and websites by the wind industry (e.g. WWEA and DWEA) and organisations campaigning against (e.g. Country Guardian and National Wind Watch) or in favour of wind energy (Yes2Wind and Embrace the Revolution). Table IV.1 summarises some areas of dispute between supporters and opponents of wind technology; a more comprehensive review can be found in Simão (2006a).

Warren *et al.* (2005) note that the wind energy debate involves strong "green" arguments on both sides. Some environmentalists advocate wind energy because of its "clean" credentials; others oppose it because of its landscape impacts (e.g. The Campaign for the Protection of Rural Wales); whilst others are awkwardly caught in the middle, supporting wind energy in principle but opposing specific wind farms (e.g. The Royal Society for the Protection of Birds (RSPB) stands in favour of wind energy as long as the wind farms do not infringe on protected habitats or migratory routes).

Arguments for	Arguments against
- is clean: it prevents the emission of several greenhouse gases, including carbon and sulphur dioxides;	- does not help to reduce carbon dioxide emissions significantly;
- is benign: it produces no harmful pollutants or waste products, nor does it have costs that are passed onto future generations;	- is inefficient and unreliable, a direct consequence of the unpredictability and intermittent nature of the wind;
- is the most cost-effective renewable energy technology;	- needs fuel-generated energy back-up for the times when the wind is calm;
- conscientious site selection and adequate landscaping and engineering practices help to minimise them;	-wind turbines are visually intrusive, spoil the landscape and destroy the countryside;
- overall impact on birds is low compared with other human-related sources of avian mortality (Erickson *et al.*, 2002);	- is hazardous for birds: many have died in collision with wind turbines (Iberica2000.org, 2005);
- house prices begin to recover once the wind farm has been up and running for two years (Royal Institution of Chartered Surveyors, 2004);	- has an adverse impact on house prices, mostly due to the visibility of wind turbines;
- modern wind turbines are quieter than in the past;	- wind turbines are noisy and have detrimental effect on people's health and quality of life (nuisance and sleep disruption are the most frequent complaints);
- creates jobs in manufacturing and other sectors indirectly involved (e.g., environmental consultancy and electrical and civil engineering).	- threatens jobs in the tourism industry due to its adverse impact on the scenic quality of the area.

Table IV.1 – Some arguments in the debate on wind energy.

IV.2.3. Public attitude to wind energy

Public attitudes to wind energy have been extensively examined in previous research (see, for example, Walker, 1995; Devine-Wright, 2005a; Krohn and Damborg, 1999; Kempton *et al.*, 2005; Toke, 2005b; British Wind Energy Association (BWEA), 2004; EWEA, 2003; DTI, 2006c; Bishop and Proctor, 1994; and Braunholtz, 2003). A remarkable consistency emerges from these surveys and case studies: large majorities of respondents favour wind power development both in principle and in practice. This stand contrasts with the impression conveyed by the media, which typically portrays massive grassroots opposition to wind farms.

Landscape and visual impacts are the most frequently mentioned objections to wind energy (Gipe, 1993; Pasqualetti *et al.*, 2002a; Wolsink, 2000; 2007; Strachan and Lal, 2004; Warren *et al.*, 2005). Interestingly, Gipe (1995) notes that people unconsciously realise that opposition on aesthetic grounds is subjective and, therefore, rationalise it by citing concerns such as noise, shadow flicker and birds, which can be evaluated objectively.

Public surveys reveal that support for local wind projects often increases once turbines enter in operation. The Delabole project, in Cornwall, is a clear example of a community's change of attitude towards wind energy. Two surveys, one before and another four months after the turbines entered service, revealed this change of attitude (Young, 1993). More recently, retrospective questionnaires have shown that opposition to wind farms arises from exaggerated perceptions of likely impacts, which experience frequently dispels (Braunholtz, 2003; Warren *et al.*, 2005). Gipe (1993; 1995) describes this growth of acceptance over time as a natural process of assimilation that parallels the assimilation processes of The Eiffel Tower and other prominent landscape features - such as bridges, viaducts or even traditional windmills - into western European culture.

It is noteworthy that the results from some surveys contradict the idea that those who live closer to wind turbines (or can see them from their houses) oppose them more strongly. Indeed, studies by Braunholtz (2003), TNS (2003), Market Research Associates (1994), Warren *et al.* (2005) and Krohn and Damborg (1999) show that people living near wind farms show positive attitudes towards them. This finding challenges the typical NIMBY (Not In My Back Yard) syndrome associated with wind energy.

IV.2.3.1. NIMBYism

NIMBYism in wind energy is defined as a positive attitude towards wind power combined with opposition to the construction of a wind farm anywhere in one's own neighbourhood (Wolsink, 2000). NIMBYism is associated with the perceived difference between the costs of wind energy (that are largely borne by local communities) and the benefits (that accrue to society in general).

Proponents of the project often label opponents "NIMBY" (Bell *et al.*, 2005; Devine-Wright, 2005a). However, the adequacy of the term for addressing local opposition has been questioned in several studies (Devine-Wright, 2005a; Kempton *et al.*, 2005; Wolsink, 1996; 2000; 2007). Two significant arguments are that:

- NIMBYism requires acceptance of the technology and this is not always present. In some cases, NIABY (Not In Anyone's Backyard), instead of NIMBY, would better describe opponents as they completely reject the very concept of wind energy. A determination to preserve the perceived naturalness and wildness of the countryside can explain a NIABY stance (see, for example, The Campaign for the Protection of Rural Wales, 2005); and
- opposition to a wind project might not be fuelled by individual cost-benefit calculations. Levels of education and income, age, and whether the person is interested in environmental issues are more influential factors in peoples' feelings towards wind farms than simple NIMBYism (Devine-Wright, 2005b; Ek, 2005). The nature of the planning and decision-making process is also critical in determining local support or

opposition to a wind farm project: the earlier and more open and participatory the process is, the more likely is public support (Khan, 2003, Devine-Wright, 2005b; Walker, 1995; Wolsink, 2000; 2007). In contrast, strong opposition may be generated if the public feels overrun by profit-driven developers in a fury of activity (Gipe, 1995; Krohn and Damborg, 1999).

Haggett and Toke (2006) discuss the strategies used by anti-wind energy campaigners to dispel accusations of NIMBYism. One approach is to stress the importance and innate value of the proposed wind farm site (not just because it happens to be nearby); another is to construct their case by favouring a different type of environmentalism, for instance, landscape protection. This second strategy is linked to the "green on green" conflict discussed earlier (Warren *et al.*, 2005).

IV.3. Wind energy in the UK

This section focuses on wind energy in the UK. More specifically, it introduces the context for the case study.

IV.3.1. The context for development: targets and support

In February 2000, the UK Government published its policy for renewable energy (DTI, 2000). The main objective was to increase the contribution of electricity supplied from renewable sources to 10% by 2010. To stimulate the market, key instruments were introduced, including:

- exemption of electricity from renewable sources from Climate Change Levy (a tax on business use of energy);
- a long term Renewable Obligation (RO) on all electricity suppliers in Great Britain to supply a specific proportion of electricity from renewable sources (which increases annually) or, alternatively, to purchase Renewables Obligation Certificates or to pay the buy out price[6] (DTI, 2001).

In February 2003, the Government published the Energy White Paper (DTI, 2003). This document emphasises the importance of using less energy and sets a framework to cut CO_2

[6] Before the introduction of the Renewables Obligation, the Non Fossil Fuel Obligation (NFFO) and the analogous Scottish Renewable Obligation and Northern Ireland Non-Fossil Fuel Obligation were the Government's major instruments for encouraging growth in the renewable energy industry. These were tendering schemes under which prospective renewable energy generators submitted competitive bids for fixed-price contracts. Since its introduction in 1994 until the end of 2005, more than 900 projects were contracted under this scheme; although only about a half has gone live (DTI, 2005). The success of the NFFO system in expanding the production of renewable electricity production has been widely criticised (e.g., Mitchell (2000) and Toke (2005c)).

emissions by some 60% from current levels by 2050, with real progress by 2020. Regarding renewable electricity, it reinforces the national commitment[7] laid down in 2000 and sets up an aspiration target for 2020: to double the 2010 renewables' share of electricity generation. Significantly, the document states that, if the intended reduction in CO_2 emissions is to be attained by 2050, renewables must contribute at least 30 to 40% of the UK's electricity generation by then (DTI, 2003: para 4.5). As a substantial contribution is anticipated from offshore wind energy, the Government committed itself to a major expansion of this industry.

In 2005, the UK Government launched a major review of the country's progress towards the goals set by the White Paper. The Energy Review Report, published in July 2006 (DTI, 2006a), spelt out two major long-term energy challenges for the UK: 1) to work internationally to tackle climate change by reducing CO_2 emissions; and 2) to ensure secure, clean and affordable energy supplies.

To address these challenges, a new Energy White Paper was published in May 2007 (DTI, 2007b). This document reiterates the 2003 aspiration for 20% of the UK electricity supplies to come from renewable sources by 2020 and confirms the intention to strengthen the RO in two ways. Firstly, by ensuring that the Obligation level is always above the installed level of renewables, up to a 20% obligation. Secondly, by banding the RO, differentiating the levels of support provided to different technologies, reflecting the fact that some are better-established and no longer need the full support of the Obligation. Moreover, the White Paper envisages a fundamental reform of the planning system to remove barriers to large-scale on- and offshore renewable electricity projects and improve access to the distribution grid for such projects.

IV.3.2. Current status

In 2006, 4.55% of the UK electricity generation was from renewable sources, up from 4.23% in 2005 and 3.58% in 2004 (DTI, 2007a); wind power's contribution was approximately 23% in 2006, and about 17% the previous year. The main contributors to this substantial increase were onshore wind, with an increase in electricity generated from 2,501 GWh in 2005 to 3,574 GWh in 2006 (+43%), and offshore wind which grew from 403 GWh in 2005 to 651 GWh in 2006 (+62%).

In the UK, in 2005, Scotland produced the largest output from wind (44%), followed by Wales (25%), England (22%) and, finally, Northern Ireland (9%). The East of England region led in

[7] The UK renewable energy target for 2010 is compatible with the indicative target proposed by EU as the UK "share" of the overall EU target for renewable energy: 10% of the UK gross electricity *consumption* to be produced from renewable energy sources by 2010.

wind-produced electricity (29%), followed by the North West region (23%) (DTI, 2006b). Similar data for 2006 will be released in September this year.

The BWEA (2006b) reports that, at the end of 2006, 1,725 wind turbines were operational throughout the UK, arranged in 135 wind farms (5 of which are offshore). Total installed capacity was nearly 1,963 MW, with 303.8 MW (15.5%) offshore. In 2006, alone, 22 wind farms (630.8 MW) came onstream, one of which is offshore (90 MW). In 2005, 19 wind farms (447.0 MW) were built, including one offshore (90 MW); with 12 built the previous year (253.7 MW), with one offshore (60 MW). At the end of 2006, 325 other wind farm projects were in the pipeline (Table IV.2).

		England	Wales	Scotland	Northern Ireland	Total
Wind farms under construction						
	Onshore	9	2	12	3	26
	Offshore	1		1		2
	Total	10	2	13	3	28
Consented projects						
	Onshore	34	7	35	5	81
	Offshore	4	2	2		8
	Total	38	9	37	5	89
Schemes in planning						
	Onshore	64	15	77	42	198
	Offshore	10				10
	Total	74	15	77	42	208

Source: BWEA (2006b)

Table IV.2 - Summaries of UK wind farms in the pipeline as of December 2006.

The most recent data (August 2007) refers the existence of 149 wind farms, consisting of 1,874 wind turbines with a total installed capacity of 2,187 MW.

A recent report commissioned by the DTI (Enviros Consulting Ltd, 2005) suggests that the future of wind energy in the UK is promising. This report concludes that, excluding biomass/coal co-firing, onshore wind (at sites with wind speed above 9 m/s) is the lowest-cost source of renewable energy with guaranteed availability in the UK.

IV.3.3. The planning framework

Wind energy planning falls within the renewable energy planning framework. In England, there are two main planning policies underlying the development of renewable energy[8]:

[8] Other relevant policies are the Planning Policy Guidance 2: Green Belts and Planning Policy Statement 9: Biodiversity and Geological Conservation, to name but two.

- Planning Policy Statement 1 (PPS 1): Delivering Sustainable Development; and
- Planning Policy Statement 22 (PPS 22): Renewable Energy.

Published in February 2005, PPS 1 sets out the government's overarching planning policies on the delivery of sustainable development through the planning system. The key policy message that relates to wind energy is expressed as:

> "Regional planning bodies and local planning authorities should ensure that development plans contribute to global sustainability by addressing the causes and potential impacts of climate change – through policies which reduce energy use, reduce emissions (...), promote the development of renewable energy resources, and take climate change impacts into account in the location and design of development."
> (Office for the Deputy Prime Minister (ODPM), 2005a: para 13)

PPS 22 was published in August 2004 and expresses the national policy on and guidance for renewable energy. It implements the positive, strategic approach to planning for renewable energy heralded in February 2000 (DTI, 2000). It sets out, in particular, that:

> "Regional Spatial Strategies and Local Development Documents[9] should contain policies designed to promote and encourage, rather than restrict, the development of renewable energy resources." (ODPM, 2004b: para 1)

PPS 22 clearly states that Regional Spatial Strategy should include the target for renewable energy capacity in the region. Moreover, it advocates a planning logic of criteria-based policies, rather than including areas of search for renewable energy within local plans. Two other important points are that PPS 22:

- gives local authorities the licence to apply a presumption in favour of renewables; and
- highlights the need for developers to involve communities early on in the process to give them the opportunity to shape a project and influence the decision-making process.

IV.3.3.1. Obtaining planning consent

As part of development control, renewable energy developers must obtain planning permission from the relevant authority to carry out their projects. For onshore wind energy projects the relevant authority is the:

[9] Following the introduction of the Planning and Compulsory Purchase Act in September 2004, the statutory development plan consists of: 1) Regional Spatial Strategies or Spatial Development Strategy for London; and 2) Local Development Documents prepared by district councils, unitary authorities or national parks authorities, and Minerals and Waste Development Plan Documents prepared by county councils (Her Majesty's Stationery Office, 2004).

- Local Planning Authority (LPA) if the development is smaller than 50 MW - in this case the final decision is made by a committee of elected councillors;
- Secretary of State[10] (DTI), under Section 36 of the Electricity Act 1989 (not the planning system), if the development is over 50 MW - in this case, the LPA is a statutory consultee in the process.

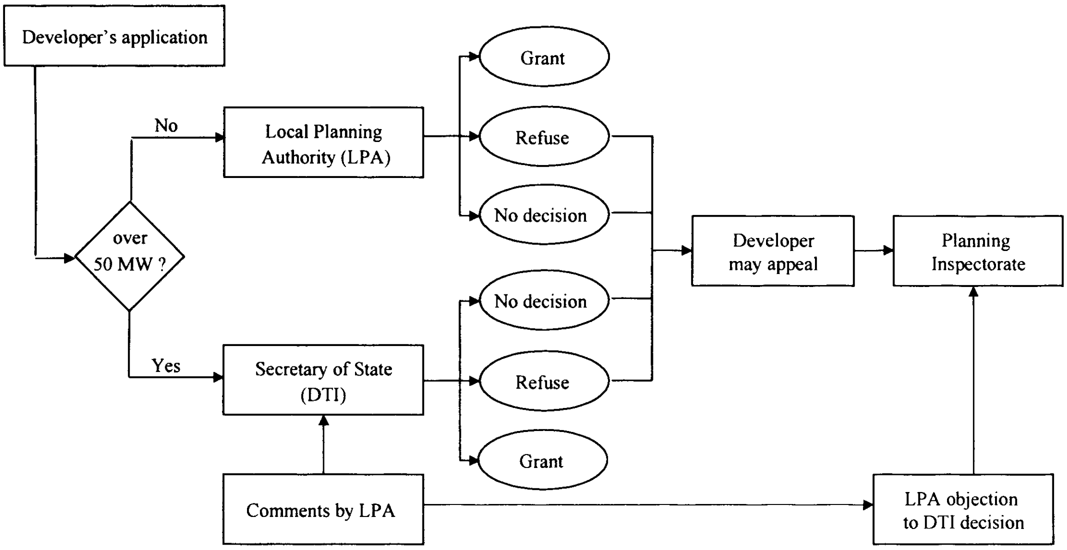


Figure IV.4 - Wind energy development control process.

Figure IV.4 depicts this process. In determining the planning application, the relevant authority balances the benefits arising out of development against the induced (local) environmental impacts. Local, regional and national planning guidance on renewable energy are material considerations for determining planning applications. Where they exist, Supplementary Planning Documents on wind energy or specific sites (as part of the Local Development Documents) are also material consideration for judging planning applications.

If the relevant authority objects to the application, its concerns must be addressed by the developer or the application may be refused. Developers have the right of appeal to the Secretary of State if an application is refused, granted subject to conditions, or has not been determined within the specified period (ODPM, 2005b: para 24). Appeals are administered by the Planning Inspectorate and, when wind farm planning applications are involved, public Inquiries are often held.

[10] Sufficient third party objections, or objections from statutory consultees, may cause a "call-in" of applications of less than 50 MW by the Secretary of State.

Wind farm projects are listed under the Schedule 2 Developments of the Environmental Impact Assessment (EIA) Regulation; hence, require an EIA if they are likely to have significant effects on the environment. The resulting Environmental Report/Statement must accompany the planning application.

IV.3.4. Community involvement in wind energy planning

PPS 22 encourages community involvement in wind energy planning at two levels:

- strategic planning; and
- site specific planning.

At a strategic planning level, community involvement is the responsibility of the regional planning bodies and the LPA. Planning Policy Statements 11 and 12 inform on conducting community involvement at regional and local levels respectively. The PPS 22 companion guide provides further guidance. In particular, it recommends that regional planning bodies carry out local seminars and workshops to engage community representatives and individuals in "the identification of a 'preferred option' " - with option meaning renewable energy technology (ODPM, 2004a: para 3.40). However, nothing is said regarding community involvement in identifying adequate areas for siting wind farms (and renewable energy developments in general), despite the fact that Regional Spatial Strategies should identify broad areas where different renewable energy developments may be located.

LPAs elaborate higher-level policies, namely by developing criteria-based policies to reflect specific local circumstances. Whilst LPA planning officers recognise the relevance of involving the public in wind energy strategic planning (Jermany, 2005; Long, 2005), they acknowledge that financial and human resources are constraints on doing so. Therefore, LPAs do not typically go beyond what is required regarding public participation, i.e. they consult the public on drafts of Local Plans and submitted planning applications. Preparation of supplementary planning policy on wind energy may create an opportunity to engage more actively with the public. Breckland District Council, for instance, during preparation of supplementary guidance promoted educational initiatives in schools on the topic wind energy and sought public opinions on renewable and wind energy through the Council newsletter and a few public meetings (Long, 2005).

At site specific level, community involvement in wind energy planning is the developers'[11] responsibility. Over the past decade, developers have been criticised for inadequate local consultation and lack of engagement with the public, which translates into poor planning applications approval rates (Toke, 2002; Walker, 1995)[12]. Following recommendations from national planning policy and best practice guidelines, developers have changed their approach. Currently, some put a lot of effort into early community consultation at a project-based level. Typical initiatives are developing liaison groups, holding local public exhibitions on the proposal and organising events that provide fora for the local community to find out more about the proposed development. Liaison groups and public events enable developers to learn about locals' concerns and to reflect them in project adjustments. The Internet has also become a means for reaching out to the public: initially used exclusively to disseminate information (e.g. the Environmental Statement of the wind farm project), it is now used to "hear" from the local community on proposals (see, for example, Your Energy's website at http://www.westwightwindfarm.com/Protected/engage-in-consultation.aspx).

With the objective of developing a consistent approach to public engagement in wind energy development, the South West Renewable Energy Agency produced a protocol outlining a series of responsibilities for LPAs and developers to promote effective community involvement in wind farm planning (South West Renewable Energy Agency, 2004). The protocol represents a statement of commitment by the signatories.

If a wind farm developer does not engage with the public, in a reactive way, the public can still participate in developing the specific project, during the consultation stage of the submitted planning application. Indeed, after receiving a planning application, the determining authority has the duty to advertise it and open a consultation period that should last, at least, six weeks after the proposal and accompanying Environmental Report/Statement are made available. To convey their views on the proposal, members of the public must write representations to the local planning officer or local councillor, which are considered during the application determination. Appeal procedures safeguard similar participation rights for the public.

[11] The model of wind power development considered here is that where the developer initiates and leads the process. This is the most common scenario in the UK context. Other models exist, such as where the project is initiated and led by the local community (Energy Saving Trust, 2005, Hinshelwood, 2001; Toke, 2005a).

[12] See section IV.2.3.1 on the influence of public involvement on the planning and decision-making process and acceptance of wind farm projects.

IV.4. The selected case study

IV.4.1. Why wind energy strategic planning?

As the last section makes clear, there are two levels at which the public can get involved in wind energy planning: strategic and site specific. I see public participation in strategic wind energy planning as a significant case study because:

- being web-based, the proposed framework will help public bodies (e.g. LPAs) to tackle the problem of human resource shortages in relation to public participation initiatives – once set up, the costs of running a web-based system are minimal;
- being learning-enhancing, the proposed framework will, hopefully, foster awareness on the nature and state of wind energy technology and contribute to put into perspective overstatements sometimes disseminated by interest groups – enabling the public to participate in local planning opportunities with a more open mind;
- the proposed framework will have greater exposure and impact: exposure because its audience is greater than just the local community concerned with a specific wind farm project; impact because it will be a medium for citizens to participate in an issue of public interest and concern – since public bodies are not proactive in eliciting views on wind farm strategic planning, most citizens may never have had the opportunity to express their opinion on this hot topic; and
- the proposed framework deals with the problem of engaging people in discussing planning problems at supra-local scales. Members of the public are naturally more attracted, and committed, to participating in local planning problems; partly because of their knowledge of the area, which enables them to contribute more confidently to planning, partly because they are an interested party in the first instance. Current web-based technologies enable developing planning solutions for large areas while keeping an eye on the local scale. The underlying principle is to extend over the whole territory the same fundaments used in devising a local solution. This "extension" will be very significant if NIMBYism (*cf.* section IV.2.3.1) occurs: it will demonstrate that a restricted number of sites are eligible for locating a wind farm (or some other form of infrastructure), if the constraints developed during local-scale analysis are applied elsewhere.

Before presenting how the selected case study application will be tackled within the proposed conceptual framework, some considerations about wind energy strategic planning are addressed.

IV.4.2. Areas of search *versus* criteria-based strategic planning

England's renewable energy policy, PPS 22, recommends criteria-based strategic planning. The arguments are:

- identification of areas of search (i.e. generalised locations with potential for wind energy development) is based on a series of assumptions regarding the technical and economical feasibility of wind energy projects. As technology evolves, sites currently excluded can become suitable in the future;
- local and regional planning authorities often do not have the expertise, resources or the experience of wind power technology to define areas of search; and
- identification of areas of search leads to a presumption against development outside these areas and possibly to excessive pressure within.

The wind industry, interested in retaining the freedom to select the most efficient and economic sites, naturally supports this stance.

Nevertheless, identifying potential or suitable development areas is a well established procedure in the planning process. It gives structure to the pattern of development, helps to allay fears about uncontrolled development and allows prospective developers to concentrate their efforts in areas where gaining planning permission is more likely. Moreover, it facilitates a level of objectivity and consistency on determining planning applications that is difficult to maintain on unplanned and market-driven developments. Finally, but not least important, it creates an opportunity for developers, planning authorities and multiple stakeholders (e.g. English Nature (EN), Ministry of Defence (MoD), local communities, etc.) to work in partnership on wind farm siting right from the earliest stages.

The first aspect - structuring the pattern of development - is of particular relevance in wind energy planning due to the cumulative effects of these developments on the landscape (for more information on this issue see, for instance, Energy Technology Support Unit (ETSU), 2000; Landscape Institute and Institute of Environmental Management and Assessment (LI/IEMA), 2002; Macaulay Institute, 1999).

A further argument for the areas of search approach to strategic planning is connected to the European Directive 2001/42/EC (European Parliament and the Council, 2001a). This directive was transposed to the UK legislation in 2004 and requires all plans and programmes with likely significant effects on the environment to be subject to environmental assessment. Wind farms are developments likely to have significant impacts on the environment - many planning applications have been refused on these grounds. Therefore, because the areas of search approach implies consideration of the local environment, facilitates discussion amongst stakeholders and suitable areas, once identified, can be used as a basis for further evaluations - namely strategic environmental assessments - this approach arguably facilitates the application of the directive 2001/42/EC. A positive outcome of this approach is that unsuitable locations for wind farm projects would be spotted earlier on, saving time, effort and money on such projects.

Demonstrating a sensitivity to at least some of these arguments, various countries (e.g. Germany and Denmark) implement a map-based approach for wind energy planning (Centre for Sustainable Energy and Garrad Hassan, 2005; Szarka and Blühdorn, 2006). In the UK, some LPAs also adopted this approach, in some instances coupled with criteria-based policies (Chris Blandford Associates, 2000): Northumberland County Council's Structure Plan and Castle Morpeth Borough Council's Local Plan are two examples.

More recently, Scotland's Highlands Council, also adopted this approach to develop its Renewable Energy Strategy, which was approved as Supplementary Planning Policy (The Highland Council, 2006). Likewise, the Welsh Assembly Government (WAG) adopted a map-based approach for the revision of Technical Advice Note (TAN) 8: Renewable Energy. Contractors used a GIS-based analysis and MCDM techniques to identify seven Strategic Search Areas for large-scale onshore wind energy developments (over 25 MW) (Power, 2004). The process involved various stakeholders; however, the wider public was only called to "examine the strategic options", rather than to contribute to the planning process. This lack of public involvement has been highlighted by various bodies, especially The Campaign for the Protection of Rural Wales which claimed that the WAG's "authoritarian approach contravenes the principles of Aarhus Convention" (Ogden, 2005).

IV.4.3. Problem statement

Based on the analysis above, the areas of search approach to wind energy strategic planning was adopted for this study. More specifically, the strategic planning problem was formulated as "*where to locate wind farms*?". This problem statement has the potential to:

- appeal to members of the public;
- be clearly perceived by members of the public; and
- be structured in such a way that the MCDM methodology can be applied.

Participating in strategic planning might be difficult for members of the public when they do not know how "impact on the landscape will be considered" nor how the underlying judgement of "impact" will be made. An approach that both "materialises" strategic planning and invites people to contribute to a planning solution certainly is more engaging.

Unclear problem statements can generate different interpretations that often lead people to resolving different problems; the result is a clear divergence from the spirit of public participation - involving the public in decision-making on a specific problem. Finally, the importance of this last point stems from the proposed framework to embed the MCDM methodology (*cf.* section III.3.2.2).

IV.5. Selecting a case study area

To implement the proposed application effectively, a case study area is necessary. Since no commitments to a specific area existed, a rational and stepwise procedure was designed to select one. Two aspects were established at departure: first, for logistical reasons, the case study area should be located in England; and, second, it should be of a manageable size. A county was considered a suitable geographic division because it simultaneously embodies a certain proximity to citizens, attracting them to contribute to their "local" environment, and a relative distance that should negate perspectives that are too locally-focused. However, three aspects led to considering using a smaller area:

- public participation initiatives require trust, which can be gained by providing reliable information. Hence, the system must provide accurate and comprehensive information. Since collecting and collating detailed information requires a great deal of time, a smaller case study area was deemed preferable *vis-a-vis* the project timeframe;
- the project will involve a series of spatial analyses that include computation of viewsheds (e.g. to estimate visual impacts of wind turbines located at a certain site). Spatial analyses involving detailed datasets are time-consuming and computationally expensive (Kidner *et al.* (1997) for example, argue for the use of parallel processing for viewshed computation). From this point of view, a small case study area is also preferable; and
- people are more likely to participate in a spatial planning initiative if they know the area; thus, a smaller case study area has the potential to attract and interest more people.

Based on these considerations, a maximum case study area of 1,600 km^2 (corresponding to a square of 40 km side) was selected. The following sections report on the methodology used to choose a case study area.

IV.5.1. Methodology: a three-stage approach

Figure IV.5 outlines the three-stage methodology designed for selecting a study area. Each stage corresponds to a successive "zoom" into the area comprising the study area.

1st stage		
Select a region	⇔	2 criteria considered
2nd stage		
Choose a county	⇔	Context analysis
3rd stage		
Further reduction of the area	⇔	Multi-criteria decision making

Figure IV.5 – The three-stage methodology adopted for selecting the case study area.

In the first stage an English region is selected using two evaluation criteria. In the second stage, a context analysis selects the county that contains the case study area. Finally, in the third stage, the case study area is selected from a set of alternatives using a MCDM analysis.

IV.5.2. First stage: selecting a region

IV.5.2.1. The decision-making procedure

The selection of a region for the case study area was based on two criteria, the region's:

- wind energy potential; and
- rate of Internet access.

The rationale behind the selection of these criteria is that: 1) wind energy potential is the baseline for discussing where a wind farm should be located; and 2) access to the Internet is a prerequisite for people to use the proposed web-based framework[13].

Regional wind energy potential was assessed using the indicative onshore wind energy target for 2010 volunteered by each region it its Regional Renewable Energy Assessment (RREA). RREA studies were set in motion in 1999, after an invitation from central government, with the objective of assessing each region's potential for renewable energy generation and setting a

[13] With this respect it seems worth noting that, at the time the case study area was selected, the experiment to evaluate the prototype was planned to be a real-world context. As the reader shall see in Chapter VII, the prototype was tested in a particular setting.

target for renewable energy provision for 2010. Table IV.3 lists the range for renewable electricity generation and onshore wind energy targets for 2010 in each region's assessment.

	Indicative targets for 2010											
	Renewable electricity generation (RE)				Onshore wind energy				Offshore wind energy			
England regions	Low (GWh)	% target[1]	High (GWh)	% target[1]	Low (GWh)	% RE[2]	High (GWh)	% RE[3]	Low (GWh)	% RE[2]	High (GWh)	% RE[3]
North East	891	2.8	2 034	6.3	580	65.1	1 230	60.5	10	1.1	10	0.5
North West	2 775	8.6	3 151	9.7	651	23.5	651	20.7	600	21.6	600	19.0
Yorkshire and the Humber	1 218	3.8	3 579	11.0	215	17.7	800	22.4	0	0.0	561	15.7
East Midlands	1 802	5.6	1 991	6.1	319	17.7	319	16.0	350	19.4	350	17.6
West Midlands	2 499	7.7	2 891	8.9	1 345	53.8	1 345	46.5	0	0.0	0	0.0
East of England	n/a	--	4 300	13.3	n/a	--	1 700	39.5	n/a	--	1300	30.2
London	224	0.7	600	1.9	22	9.8	22	3.7	0	0.0	0	0.0
South East	1 432	4.4	3 262	10.1	147	10.3	303	9.3	160	11.2	640	19.6
South West	1 193	3.7	2 534	7.8	390	32.7	716	28.3	0	0.0	160	6.3

[1] Percentage of Great Britain's Renewable Obligation target for 2010: 32.4 TWh

Source: Oxera Environmental and Arup Economics and Planning (2002)

[2] Percentage of the low target of renewable electricity generation

[3] Percentage of the high target for renewable electricity generation

Table IV.3 - Regional renewable and onshore wind electricity production targets for 2010.

Table IV.3 reveals that the East of England volunteered the highest target for onshore wind generated electricity for 2010 (1,700 GWh). The North East region has the highest ratio of onshore wind generated electricity to all renewable-source generated electricity targets (60.5%, considering high estimates).

Regional rates of Internet access were assessed using statistics on individual Internet access and households with home access to the Internet. These data are provided by the Office for National Statistics (ONS) on a regular basis. The data source is the National Statistics Omnibus Survey for individuals' use of the Internet and the Expenditure and Food Survey for household data[14]. At the time of the analysis, the most recent data available on individuals' use of the Internet were for the period April 2003 - February 2004. At the time of writing, more recent data are available. Table IV.4 provides an overview of the evolution of this indicator. For the analysis, however, only the year 2003/04 was considered (highlighted in blue in Table IV.4).

In this period, the London and South East regions had the highest proportion of adults that had used the Internet in the three months prior to the ONS interview (both with 64%). While the East of England and the South West registered the next two highest proportions, 59% and 58% respectively, the lowest level occurred in the North East (43%). In 2004/05 the scenario was slightly different: the East of England and South East regions had the highest percentage of individuals using of the Internet, both with 66%.

[14] After May 2005 the National Statistics Omnibus Survey became the source for data on households and individuals.

	% of adults who have accessed the Internet[1]				
	April to February			evolution	
England regions	2001/02	2003/04	2004/05	2002/04	2004/05
North East	37	43	48	6	5
North West	44	57	59	13	2
Yorkshire and the Humber	44	56	54	12	-2
East Midlands	44	54	62	10	8
West Midlands	47	55	54	8	-1
East of England	55	59	66	4	7
London	59	64	65	5	1
South East	52	64	66	12	2
South West	49	58	61	9	3

[1] Source: National Statistics Omnibus Survey (ONS, 2007)

Table IV.4 – Regional breakdown of Internet access: percentage of adults who have used the Internet in the 3 months prior to the survey's interview.

At the time of analysis the most recent data available on households with home access to the Internet was for the period October 2002 – September 2003; data are now available for the years 2005 and 2006 (Table IV.5).

	Households with Internet access		
England regions	Oct 2002 - Sept 2003[1]	2005[2]	2006[2]
North East	43	43	54
North West	43	51	54
Yorkshire and the Humber	43	50	51
East Midlands	48	58	55
West Midlands	46	55	52
East of England	48	57	63
London	52	53	62
South East	53	62	66
South West	43	54	58

[1] Source: Internet Access - Households and Individuals (ONS, 2003)

[2] Source: Internet Access - Households and Individuals (ONS, 2006a)

Table IV.5 - Regional breakdown of households with home access to Internet: percentage of households interviewed.

The South East and London regions had the highest proportion of households with home access to the Internet (53% and 52%, respectively). The East of England and East Midlands regions shared the third position in the ranking, both with 48%. In 2006, the South East region continues at the top of the ranking (66%) with the East of England region in the second position (63%). Yorkshire and Humber region has the lowest access level (51%).

A simple procedure was applied to select the region for the study area: candidate regions were ranked by their performance on each evaluation criterion and a final ranking was computed as the sum of these rankings. Since the criterion "Internet access" includes two facets, individual and household access, these were summed to provide an overall criterion ranking. Table IV.6 summarises the procedure.

	Onshore wind energy potential		Internet access					
	regional target		Individual access		Households access		criterion ranking	final ranking
English regions	High (GWh)	ranking	Apr 03 - Feb 04	ranking	Oct 02 - Sept 03	ranking		
North East	1 230	3	43	9	43	6	9	4
North West	651	6	57	5	43	6	5	3
Yorkshire and the Humber	800	4	56	6	43	6	7	3
East Midlands	319	7	54	8	48	3	5	4
West Midlands	1 345	2	55	7	46	5	7	2
East of England	1 700	**1**	59	3	48	3	**3**	**1**
London	22	9	64	1	52	2	2	3
South East	303	8	64	1	53	1	1	2
South West	716	5	58	4	43	6	4	2

Table IV.6 - Selection of the region comprising the case study area.

From this analysis, the East of England region emerges as the best compromise: it has the best regional onshore wind energy potential and occupies third position on level of Internet access by its inhabitants. A suitable case study area will be identified within this region.

IV.5.2.2. East of England: the selected region

The East of England region stretches from the edge of London in the south to the coast in the north and east. It covers an area of 19,120 km^2 and comprises 6 counties (Cambridgeshire, Norfolk, Suffolk, Bedfordshire, Hertfordshire and Essex) and 4 unitary authorities (Peterborough on the northwest, Luton on the southwest, Thurrock and Southend-on-Sea, both on the south), Figure IV.6. The region's boundaries were revised in April 2001 to include parts of the former East Anglia and South East regions.

In 2004, the population was estimated at nearly 5.5 million, 60.9% of which were of working age (between 16 and pension age) and 19.6% under 16 years old (Taylor, 2006). The region contains no dominant conurbations and more than a third of the residents live in settlements of less than 10,000 inhabitants; rural areas cover some 79% of the region. The ONS publication, Region in Figures – East of England, provides more information about this region (Phillpotts and Cohen, 2004).

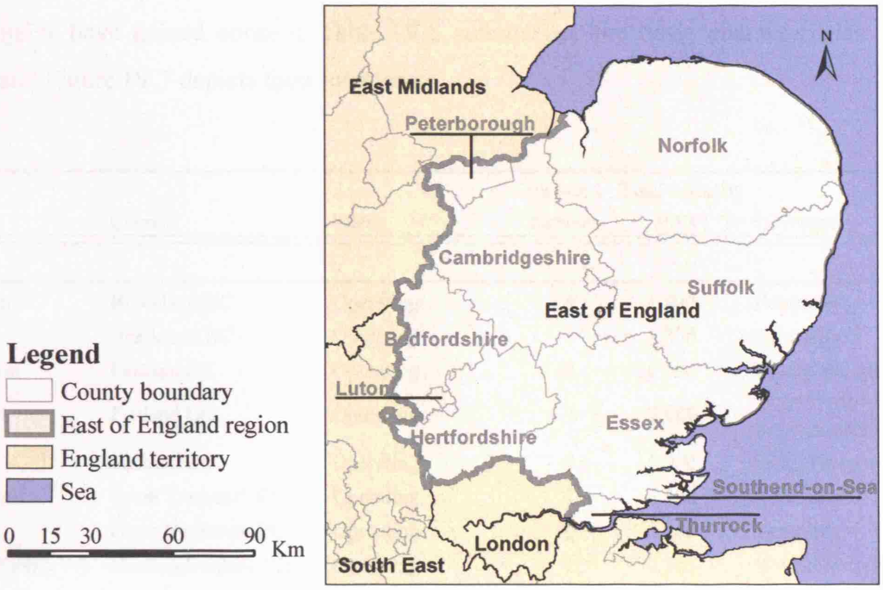


Figure IV.6 - East of England boundary and constituent local authorities

The East of England Plan (Policy ENV8: Renewable energy and energy efficiency; East of England Regional Assembly, 2004)[15] sets out the region's policy for renewable energy. Complying with a PPS 22 recommendation, the East of England Plan adopts renewable energy targets for 2010 and 2020, see Table IV.7.

East of England's renewable energy targets			
2010		2020	
Excluding offshore wind	Including offshore wind	Excluding offshore wind	Including offshore wind
10%	14%	17%	44%

Table IV.7 - Renewable energy targets for 2010 and 2020 expressed as the percentage contribution of renewables to total electricity consumption in the East of England.

The 14% target for 2010 (including offshore) corresponds to the production of 4,300 GWh of electricity pointed out in Table IV.3. County targets proposed in the RREA (Hams *et al.*, 2001) were not taken forward by the East of England Plan.

Eleven onshore wind farms were up and running in the East of England in November 2006, three more were under construction and six others projects had been approved. The operational capacity totalled 44.5 MW and the projects in the pipeline represented a further 81.6 MW of

[15] At the time of writing, the East of England Plan has already undergone the consultation stage and a final publication is expected in the autumn of 2007.

capacity. Offshore, the Scroby Sands wind farm has been operating since June 2004 and two other projects have gained consent. Table IV.8 summarises the basic characteristics of these projects and Figure IV.7 depicts their locations.

Project name	Council	Status	Nr wind turbines	Total capacity (MW)	Developer
ONSHORE					
Ecotech Centre	Breckland DC	Operating	1	1.500	Ecotricity
Swaffham II	Breckland DC	Operating	1	1.800	Ecotricity
Coldham Farm	Fenland DC	Operating	8	16.000	Co-Op and others
Long Hill Rd	Fenland DC	Operating	1	2.000	Wind Prospect & Snowmountain Lda
Glass Moor	Fenland DC	Operating	8	16.000	Wind Prospect
West Somerton	Great Yarmouth BC	Operating	1	1.500	Ecotricity
Blood Hill	Great Yarmouth BC	Operating	10	2.250	Ecotricity
Kings Bush Farm	Huntingdonshire CD	Operating	1	0.225	Wood Green Enterprises
Abbey Produce	Huntingdonshire CD	Operating	1	0.225	Fivestones Lda
RES Headquarters	Three Rivers DC	Operating	1	0.225	RES
Ness Point - 2	Waveney DC	Operating	1	2.750	SLP Energy
Ranson Moor Farm	Fenland DC	Under construction	3	6.000	Fenpower Ltd
Red Tile Farm	Huntingdonshire CD	Under construction	12	24.000	Wind Prospect
Parham Airfield	Suffolk Coastal DC	Under construction	6	7.800	Your Energy
North Pickenham	Breckland DC	Approved	8	16.000	Enertrag UK
Shipdham	Breckland DC	Approved	2	4.000	Ecotricity
Stags Holt	Fenland DC	Approved	9	15.750	Powergen Renwables
French Farm	Peterborough CC	Approved	2	0.450	All Wind UK Lda
Wryde Croft	Peterborough CC	Approved	7	7.000	RES UK Lda
Ness Point - 1	Waveney DC	Approved	1	0.600	Ecotricity
OFFSHORE					
Cromer	6.5 km off Foulness	Consented	30	100	Norfolk Offshore Wind Ltd
Scroby Sands	3 km off Gt Yarmouth	Operating	30	60	E.ON UK Offshore Wind Lda and Vestas
Gunfleet Sands	7km off Clacton on Sea	Consented	30	108	GE Gunfleet Lda

Source: BWEA website (2006) and other web resources

Table IV.8 - Wind energy in East of England: operating, under construction and approved projects (as of November 2006).

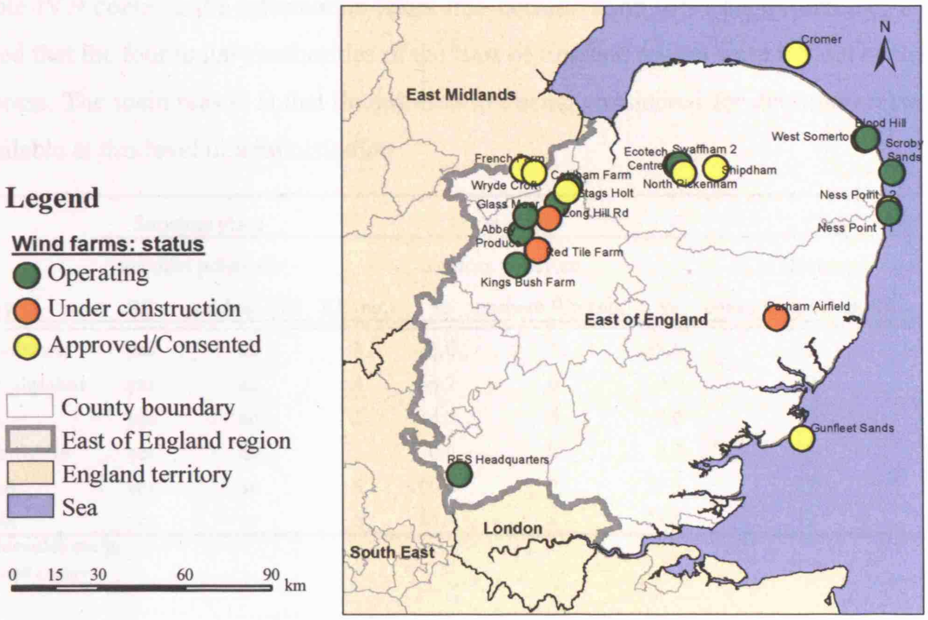


Figure IV.7 – Wind farm status in the East of England (as of November 2006).

IV.5.3. Second stage: identifying a county

The second stage of the methodology selects a county by considering the following aspects:

- counties' and respective LPAs' policies on renewable and wind energy; and
- counties' potential for, and internal willingness to realise, wind energy generation.

The first aspect was analysed using a review of renewable energy policies conducted for the East of England Sustainable Development Round Table during the preparation of the RREA (Hams *et al.*, 2001). As this review preceded the creation of the East of England region (April 2001), its source material included the Regional Planning Guidance (RPG) 6: East Anglia and RPG 9: South East, plus the Structure Plans of the included counties and the Local Plans of the respective LPAs. These documents are still valid today and will continue in use until the provisions of the Planning and Compulsory Purchase Act 2004 enter into force. Plan documents adopted after June 2000 (the data of publication of the review) were reviewed in the frame of this analysis to ensure the correctness of information used.

The second aspect (counties' potential for wind energy generation) was assessed using the county targets for wind electricity generation proposed by the RREA (Hams *et al.*, 2001). These targets result from a concerted process involving several stakeholders and are assumed to reflect both a county's potential for wind energy generation and its internal willingness to realise this potential.

Table IV.9 contains the information taken into consideration for decision-making. It should be noted that the four unitary authorities of the East of England region were left out of the selection process. The main reason is that the information being considered for decision-making was not available at this level of administration.

	Structure plans		Local plans				Targets for 2010	
	includes policy on		includes policy on				% of electricity	wind electricity
County	RE	onshore WE	RE (no.)	%	onshore WE (no.)	%	consumption from RE	(GWh/yr)
Bedfordshire	yes	no	3	75.0	1	25.0	13	170
Cambridgeshire	yes	no	4	66.7	0	0.0	9	290
Essex	yes	no	2	14.3	0	0.0	9	478
Hertfordshire	yes	no	3	30.0	0	0.0	3	96
Norfolk	yes	no	8	100.0	3	37.5	17	419
Suffolk	yes	no	6	85.7	2	28.6	12	273

RE: renewable energy
WE: wind energy

Table IV.9 - Aspects taken into account to decide which county will contain the study area.

Every structure plan in the East of England region includes policies for renewable energy but not for onshore wind energy. All LPAs in the county of Norfolk have included policies on renewable energy in their Local Plans, and three out of eight (37.5%) included policies on onshore wind energy; two Local Plans address single or small-groups of wind turbines. The county of Essex provides the least guidance on these topics: only two LPAs (14.3%) set out policies on renewable energy and none issued policies on onshore wind energy. Essex agreed to generate the highest amount of wind-generated electricity (478 GWh by 2010), closely followed by Norfolk with a target of 419 GWh.

Based on a qualitative assessment, Norfolk county was selected to be taken into the third stage of the methodology. Supporting arguments include:

- Norfolk's adopted Structure Plan supports renewable energy development (Policy RC.9), although it includes relatively strict directives for judging wind farm planning applications;
- Norfolk has the most comprehensive coverage of renewable energy policies of all counties;
- Norfolk has a high wind energy generation potential, reflected in the target that has been proposed for the county;
- At the end of 2004, when this analysis was carried out, Norfolk had 7.05 MW of installed wind energy capacity. Assuming a load factor of 42% (as implied in Hams *et al.*, 2001), about 26 GWh of electricity were generated annually in Norfolk from wind

power. If something closer to the suggested target for 2010 (419 GWh) is to be accomplished, a significant number of wind turbines still need to be located[16]. Hence, Norfolk is a pertinent area to work with.

- Finally, long-running and newly installed wind energy developments mean that wind energy is quite a prevalent topic in Norfolk. The oldest wind energy development is Blood Hill wind farm (10 turbines), in Great Yarmouth, operating since December 1992; in December 2004, 30 offshore wind generators, visible from great distances due to the flat terrain in the area, were switched on (Scroby Sands wind farm)[17]. Thus, the population is aware of the technology and potentially are interested in getting actively involved in the planning process for these "close" developments.

IV.5.4. Third stage: picking up the case study area

A MCDM analysis (*cf.* section II.3.2.2) is used in the third stage of the methodology to identify the case study area. The adoption of such a technique is justified by the fact that there are multiple competing factors to be considered, including: the population of the area (the more potential system users, the better); the size of the area (based on the points discussed above, the smaller the better); and access to the Internet (the broader, the better since the proposed system is Internet-based). The following sections report on the application of the MCDM methodology.

IV.5.4.1. Identifying the evaluation criteria

The DM for this problem is the author. Ten attributes (evaluation criteria) were identified to select a case study area from amongst the alternatives, Table IV.10.

The evaluation criteria were grouped into three families. Family A comprises three wind energy criteria. Criterion A.1 evaluates the proportion of competing case study areas that are feasible wind farm sites - the larger this area, the more attractive is the alternative. Criterion A.2 appraises the interest that each alternative study area has received from wind energy developers using the number of wind farm planning applications received by the LPA. Criterion A.3 estimates the level of awareness of wind energy in the area: the greater the number of recent

[16] If wind turbines of 1,5 MW capacity are considered (the most popular model in 2004), 72 wind turbines would need to be accommodated over the next 6 years to produce the 393 GWh in deficit for the county's target.

[17] Another offshore wind farm project has also gained consent – Cromer offshore wind farm to be constructed 6.5 km off Foulness, on the north of Norfolk county. Other projects will also spring in the Great Wash basin, in accordance to the results of the "Round 2" of offshore wind development (BWEA, 2007).

applications (Nov. 2000 – Nov. 2004[18]), the greater the awareness of the topic and, potentially, the greater the interest of the public in participating in the strategic planning of wind farms.

Evaluation Criteria		
Identification	Designation	Specification
A - Wind energy related issues		
A.1	Feasible area	Area of feasible sites for wind farm accommodation within the case study area
A.2	Developers' interest	Total number of wind farm planning applications received by the area's LPA(s)
A.3	Awareness of the topic	Number of wind farm planning applications received by the area's LPA(s) in the past 4 years
B - Targeted public related issues		
B.1	Potential participants	Population living in the area
B.2	Onshore experience	Whether or not there are onshore wind farms operating in the area
B.3	Offshore experience	Current development status of offshore wind energy in the area
C - Workload and research design related issues		
C.1	Total surface	Area of the case study area
C.2	Nr of authorities	Number of local authorities with jurisdiction over the area
C.3	Urban population	Ratio between urban and total population living in the area
C.4	LPAs' concern	Area's LPAs "investment" in wind energy planning (policies and siting studies)

Table IV.10 – Evaluation criteria organised by families.

Family B includes three evaluation criteria that relate to the public. Criterion B.1 assesses the size of the local population - because local inhabitants are potential participants in strategic planning, the more populated an alternative, the more likely it is to be selected. Criterion B.2 evaluates each population's experience with wind energy using the number of operating wind farms. It is assumed that people living in areas with operating wind turbines have more experience which will reflect on their potential contribution to strategic planning. Thus, alternatives with operating wind turbines are more attractive than those without. Criterion B.3 is somewhat similar to Criterion B.2, but focuses on offshore wind energy. Offshore wind energy *per se* is not relevant because the current research focuses on planning onshore wind farms. However, experience on, and information about, offshore wind energy is considered to affect individuals' perception of the technology. Experience of offshore wind energy was rated higher than no experience.

Family C embraces four criteria that relate to the workload involved in processing information and testing the envisaged prototype. Criterion C.1 evaluates the area of the alternative case study areas. The larger the area, the greater the workload in processing the datasets and the less attractive the alternative as the case study area. Criterion C.2 is a measure of the number of

[18] This period was constructed based on two important moments: November 2004 was the time this analysis was carried out; November 2000 was the publishing date of Government's Climate Change - The UK Programme, which first establishes the requirement for suppliers to increase the provision of electricity from renewable energy sources to 10% by 2010 (Department for Environment Food and Rural Affairs (DEFRA), 2000).

LPAs with jurisdiction[19]. The more LPAs involved, the greater the workload (more contacts, more sources material, etc.) and the less attractive is that alternative. Criterion C.3 is a proxy for Internet access: it is assumed that the urban population has a higher rate of Internet connectivity than the rural population. Consequently, the urban population is potentially more easily able to participate in an organised event[20] and, therefore, the more urban area is the more attractive case study area. Finally, criterion C.4 considers the LPAs' level of commitment to wind energy development. In this context, commitment means: 1) whether Local Plan(s) contain(s) specific policy(ies) on onshore wind energy; 2) whether LPA(s) has(ve) carried out studies to guide wind energy development (for instance, evaluation of the landscape's capacity to accommodate wind energy projects); and 3) whether LPA(s) has(ve) developed Supplementary Planning Guidance on wind energy. The attractiveness of an alternative is directly proportional to the number of policies and guidelines that concern onshore wind energy development or, in other words, the LPAs' concern with that issue.

IV.5.4.2. Developing alternative case study areas

Alternative case study areas were developed in close proximity to the evaluation criteria. In particular, the following points were addressed:

- potential for wind energy development;
- awareness of the topic wind energy;
- relatively small area – a maximum of 1,600 km^2 as stipulated earlier;
- urban areas are preferable to rural areas; and
- population and LPA have some experience with wind energy.

Six alternative case study areas were identified: four districts (King's Lynn and West Norfolk, North Norfolk, Brekland and Great Yarmouth) and two composite areas including parts of several districts, depicted in Figure IV.8. The boundaries for the composite districts are based on regular shapes designed to include the areas with the most wind energy potential, according to the DTI wind speed dataset. Table IV.11, lists some characteristics of these areas.

[19] For the purpose of this analysis The Broads Authority, responsible for The Broads area, akin to a National Park, was considered a LPA.

[20] This assumption presupposes that the more spatially concentrated the population, the more likely the public are to participate in an event organised for testing the prototype. The rationale is that they would live closer to the public facility (library or district council) where the event was to take place. Note that at this time a real-world event was planned. As the reader shall see in Chapter VI, the testing was conducted in a particular setting.

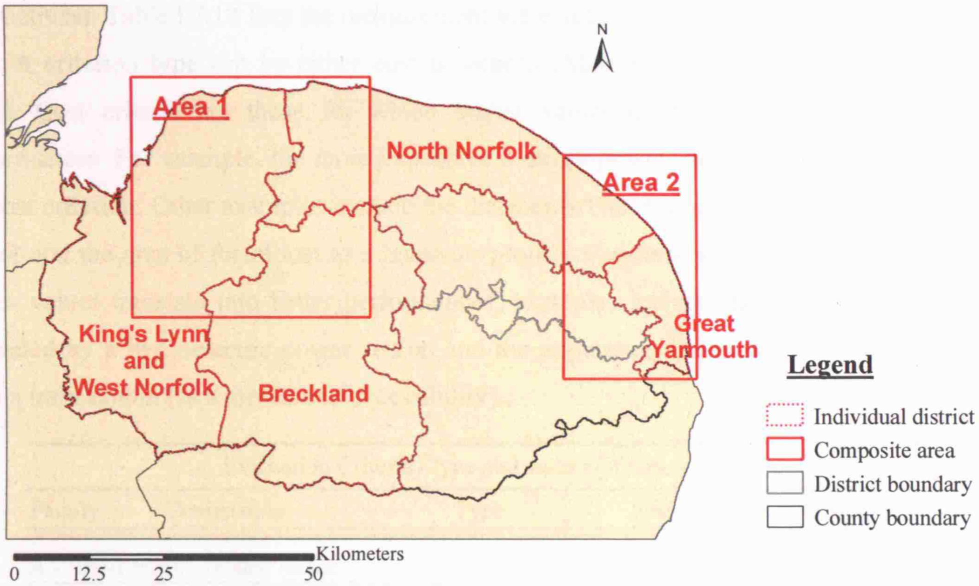


Figure IV.8 – Six alternative case study areas.

King's Lynn and West Norfolk is the largest district and Great Yarmouth district is the smallest. On the other hand, Great Yarmouth is the district most densely populated, with twice the population per km^2 of Area 2, the next most densely populated.

Alternative	LPA with jurisdiction upon the area	Land surface (km^2)	Population (inhab. 2001)	Population density (inhab/km^2)	Designated areas (% total area)
North Norfolk	North Norfolk District Council The Broads Authority	994.64	98 494	99.02	29.99%
Great Yarmouth	Great Yarmouth Borough Council The Broads Authority	182.55	90 874	497.80	38.86%
King's Lynn & West Norfolk	Borough Council of King's Lynn & West Norfolk	1 513.00	135 246	89.39	18.37%
Breckland	Breckland District Council	1 305.12	121 449	93.06	17.94%
Area 1	Borough Council of King's Lynn & West Norfolk North Norfolk District Council Breckland District Council	1 453.02	152 966	105.27	21.22%
Area 2	North Norfolk District Council Great Yarmouth Borough Council Broadland District Council South Norfolk District Council The Broads Authority	560.76	131 925	235.26	42.16%

Table IV.11 - Basic characteristics of the alternative case study areas.

IV.5.4.3. Assessing the alternatives

Assessing the alternatives involves evaluating their performance on each criterion. This section deals with the *operationalisation of the evaluation criteria* and culminates with the presentation of the so called *decision matrix* (*cf.* section II.3.2.3, sub-sections Evaluation criteria and Alternatives). Table IV.12 lists the measurement scale adopted for each criterion and respective type. A criterion type can be either cost or benefit (Malczewski, 1999a; Yoon and Hwang, 1995). Cost criteria are those for which higher values on the criterion represent lower performances. For example, the more expensive a development, the worse its performance on the cost criterion. Other examples include the distance between a neighbourhood and a primary school and the area of forest lost to a reservoir project. Conversely, benefit criteria imply that higher values translate into better performances; examples include the quantity of electricity generated by a hydroelectric power station and the population living within 10 minutes walk from a train station (as a measure of accessibility).

Evaluation Criteria - type and scale of measurement			
Family	Designation	Type	Scale of measurement (unit)
A - Wind energy-related issues			
A.1	Area of feasible sites	benefit	ratio (km^2)
A.2	Developers' interest	benefit	ratio (no. of applications)
A.3	Awareness of the topic	benefit	ratio (no. of applications)
B - Targeted public-related issues			
B.1	Potential participants	benefit	ratio (inhabitants)
B.2	Onshore experience	--	nominal (2 levels)
B.3	Offshore experience	--	nominal (3 levels)
C - Experiment-related issues			
C.1	Total surface	cost	ratio (km^2)
C.2	Nr of authorities	cost	ratio (no. of authorities)
C.3	Urban population	benefit	ratio (%)
C.4	LPAs' concern	--	nominal (5 levels)

Table IV.12 – Characterisation of the criteria in terms of type and scale of measurement.

Two types of measurement scales have been considered: ratio scales and nominal scales. The former are used to measure variables in meaningful numbers; the latter are used when no quantitative information is available to assess performance on the criterion.

To assess a candidate study area's performance on Criterion A.1, feasible areas for wind energy development need to be identified. The UK offshore wind farm planning process requires wind energy developers to make public preferred sites (BWEA, 2007). Unfortunately, a similar process has not been implemented for onshore wind energy development, so preferred sites are confidential. The process that wind energy developers apply to identify these sites is nevertheless known. Fundamentally, it consists of applying a number of criteria/constraints to exclude technically infeasible or economically unattractive areas from analysis; all remaining areas are potentially interesting for wind energy development.

A number of documents elucidate these criteria/constraints to select potential sites for a wind farm (e.g. Baban and Parry, 2001; BWEA, 1994; 2005; EN *et al.*, 2001; Hillring and Krieg, 1998; Kidner, 1997; Kidner *et al.*, 1999; Klassen and Marjerrison, 2002; Miller *et al.*, 1994; Sparkes and Kidner, 1996). Some published criteria are conflicting: while some documents state that wind turbines should not be located within 100 m from dwellings, others say they should be, at least, 500 m away. To identify current practice, the BWEA was contacted. Based on the literature and contact with the wind energy industry, a list of criteria/constraints was finally put together (Table IV.13).

Criteria for identifying feasible areas for onshore wind energy development			
Constraints	Specification	Dataset	Dataset source
Wind resource	wind speed >= 6.5 m/s	NOABL windspeed data @45m agl[1]	Dpt of Trade and Industry
Occupied land and technically unfeasible	Lakes	Land-form PANORAMA	Ordnance Survey
	DLUA[2] + 400m buffer	" "	" "
	Woodland + 500m buffer	" "	" "
	Ancient woodland + 500m buffer	downloaded from MAGIC	English Nature
	Existing wind turbines + 300m buffer	digitized from 1:50k Colour Raster	Ordnance Survey
Designated areas for nature conservation	Sites of Special Scientific Interest (SSSI)	downloaded from MAGIC	English Nature
	National Nature Reserves (NNR)	" "	" "
	Ramsar sites	" "	" "
	Special Protection Areas (SPA)	" "	" "
	Special Areas of Conservation (SAC)	" "	" "
Designated areas for landscape protection	National Parks	downloaded from MAGIC	Countryside Agency
	Heritage Coast	" "	" "
	Areas of Outstanding Natural Beauty	" "	" "
Designated areas for birds protection	Important Bird Areas (IBA)	downloaded from MAGIC	The Royal Society for the Protection of Birds (RSPB)
	RSPB Reserves	" "	

[1] agl: Above Ground Level

[2] DLUA: Developed Land Use Areas

Table IV.13 – List of constraints that identify feasible areas for siting wind farms and the datasets and respective sources used to operationalise them.

Only areas with annual mean wind speed greater than 6.5 m/s at 45 m above ground level were considered potential wind farm sites; all occupied and technically unfeasible areas were excluded (e.g. lakes, woodland, etc.) as well as all nationally and internationally designated sites (nature conservation designations, etc.).

PPS 22 states that designated sites should not be considered "no-go" areas for wind energy developments. Nevertheless, wind farm developers generally agree that obtaining planning permission for projects on these areas involves additional difficulties (there is the need to demonstrate that there is no significant environmental detriment to the area, or an overriding national need for the project, or no suitable alternative site can be found elsewhere), so these areas have been excluded from analysis. Following PPS 22, no "buffer zones" were considered around designated sites.

In addition to the constraints listed in Table IV.13, others exist that are taken into consideration by developers when searching for a wind farm site, including those imposed by the MoD and Civil Aviation Authority (CAA) (see BWEA, 2006a; Poupart, 2003; Wind Energy, Defence and Civil Aviation Interests Working Group, 2002), terrain slope and the prevailing wind direction. These constraints are typically analysed on a case-by-case basis and with a specific wind farm project in mind; hence, they have not been considered in this "batch" analysis.

Subsequently, a GIS-based "sieve mapping" approach was applied[21] to identify all feasible sites for wind energy development within each alternative and, eventually, the total feasible area for each alternative was computed.

Criterion A.2 – Developers' interest in the alternative study areas and Criterion A.3 – Awareness of the topic depend on the same dataset: the number of wind farm planning applications received by the LPA. Table IV.14 lists the information provided by LPAs.

District	Wind farm designation	Developer	Application date	Status
North Norfolk	Bodham	Private	Mai-93	refused on appeal
	Gresham	New Generation Projects Lda	Out-93	withdrawn from appea
	Ingham	Private	Dez-93	withdrawn
Great Yarmouth	Bure Loop		old project	refused
	Blood Hill	E.ON UK Renewables	Jun-91	operating
	Somerton	Ecotricity	1999	operating
	South Denes	Ecotricity	1999	approved on appeal
King's Lynn and West Norfolk	Choseley Farm	Parkers of Leicester	Fev-02	refused
	Sedgeford	Ecotricity	Set-02	refused
Breckland	EcoTech Centre	Ecotricity	1998	operating
	Swaffham II	Ecotricity	2002	operating
	North Pickenham	ENERTRAG UK Ltd	Abr-04	approved
	Shipdham	Ecotricity	Mar-04	in planning
Broadland	Guestwick	ENERTRAG UK Ltd	early 2004	in planning
South Norfolk	Stockton	Western Windpower Lda	Jul-98	refused
	Brundish	Western Windpower Lda	Jul-98	refused
Norwich	--	--	--	--

Table IV.14 - Submitted applications for wind energy projects in Norfolk (as of November 2004).

Criterion B.1 – Population of area was determined from two datasets: the usual resident population *per* Output Area (OA), from the 2001 Census at the finest level of disaggregation

[21] Figure V.3 (next chapter) illustrates this procedure.

available, and the OA boundaries. After joining the two datasets, the population resident in each of the alternative areas was estimated[22].

Performance on Criteria B.2 and B.3 was measured on nominal scales. For criterion B.2, two levels of performance were considered on a binomial measurement scale: existence *versus* absence of operating onshore wind farms in the area. For criterion B.3, three levels of performance were defined: areas with no coastline, areas with real potential for offshore wind energy development and areas with operational offshore wind turbines rated 0, 60 and 100[23], respectively. A higher value implies that the population has greater experience of wind energy technology.

Performances on Criterion C.1 – area of the alternative case study areas were easily computed using the GIS function area calculator. Only inland areas were considered for Areas 1 and 2. Criterion C.2 – Number of authorities with jurisdiction in the alternative area did not require any type of operationalisation.

To estimate performances on criterion C.3 – Ratio between urban population and total population living within each alternative area, urban areas needed to be identified. A join project between several UK Government Departments produced a rural and urban classification of various geographic units (wards, super OAs and the OAs). A first classification was released in 2004 and updated in 2005 (ONS, 2006b). Criterion C.3 was operationalised based on the 2004 classification of OAs, the most recent at the time, and Census 2001 resident population data for OAs. Later, in August 2005, Norfolk County Council (NCC) published a booklet with the desired information (NCC, 2005).

Performances on Criterion C.4 were also assessed using a nominal scale that was subsequently quantified (Table IV.15). Only real levels of performance, and two others used for reference, were included in this scale.

[22] For Area 1 and Area 2, when more than half of an OA fell within the Area, the entire population was counted; otherwise no population was counted. This simplification was expected to balance out and was found compatible with the level of detail inherent to the analysis undertaken.

[23] Levels of performance were defined by the DM (the author). The quantification of these levels followed an adaptation of the swing method for weighting decision criteria (von Winterfeldt and Edwards, 1986). First, the levels of performance were ranked by preference with a value of 0 given to the least preferred level and 100 to the most preferred. Intermediate levels are evaluated with reference to the extreme levels.

Criterion C.4 - LPA' concern		
Level	Description	Value
1	Area covered by LP without wording on wind energy	0
2	Area covered by LP with specific policy/policies on wind turbines and/or wind farms	40
3	Area covered by policies with different levels of detail, ranging from no policy to SPG on wind energy	40
4	Area covered by SPG on Wind Energy	50
5	Area covered by LP without specific policy on wind energy and a study instructing about preferable locations for wind energy projects	70
6	Area covered by policies with different levels of detail, ranging from no policy to SPG on wind energy, and partially covered by a study instructing preferable locations for wind farms	80
7	Area covered by SPG on wind energy and a study instructing preferable locations for wind energy projects	100

LP - Local Plan(s)
SPG - Strategic Planning Guidance

Table IV.15 - Specification of levels of impacts in the criterion C.4.

Table IV.16 compiles the performances of the six alternatives being evaluated on the 10 evaluation criteria.

	Evaluation Criteria									
	A.1	A.2	A.3	B.1	B.2	B.3	C.1	C.2	C.3	C.4
Alternatives	Feasible area (km^2)	Developers' interest (no.applic.)	Awareness of the topic (no.applic.)	Potential participants (no. inhab.)	Onshore experience (value)	Offshore experience (value)	Total area (km^2)	No. of LPA (no.)	Urban population (%)	LPA' concern (value)
North Norfolk	45.65	3	0	98 494	0	60	994.64	2	12.15	40
Great Yarmouth	8.10	4	0	90 874	1	100	182.55	2	73.47	40
King's Lynn and West Norfolk	99.40	2	2	135 246	0	60	1 513.00	1	32.64	70
Breckland	21.21	4	3	121 449	1	0	1 305.12	1	32.64	100
Area 1	130.29	5	4	152 966	1	60	1 453.02	3	38.04	80
Area 2	17.37	5	0	131 925	1	100	560.76	5	50.61	40
Type of criterion	benefit	benefit	benefit	benefit	benefit	benefit	cost	cost	benefit	benefit

[1]refer to Table IV.13
[2]refer to Table IV.14
[3]refer to Table IV.15

Table IV.16 – Decision matrix for selecting the case study area problem.

The decision matrix is already in its final form as it does not contain any dominated alternative. An alternative is dominated when another alternative performs at least as well on all criteria and strictly better on at least one criterion (*cf.* section II.3.2.3, sub-section Alternatives).

IV.5.4.4. Weighting the evaluation criteria

The relative importance of each criterion to decision-making was obtained using the swing weight elicitation procedure described in Edwards and Barron (1994). This technique was selected for its theoretical robustness and straightforward application. Table IV.17 shows the criteria weights.

	Evaluation Criteria									
	A.1 Feasible area	A.2 Developers' interest	A.3 Awareness of the topic	B.1 Potential participants	B.2 Onshore experience	B.3 Offshore experience	C.1 Total area	C.2 No. of LPA	C.3 Urban population	C.4 LPA' concern
Ranking	1	8	3	5	6	7	6	4	2	4
Weights	100	30	80	60	50	40	50	70	90	70

Table IV.17 - Ranking and criteria weights.

Criterion A.1 was considered the most important evaluation criterion, followed by criterion C.3. The least important criterion is A.2, with 30% of the importance of criterion A.1, the most important.

IV.5.4.5. Decision-making

For simplicity, the SAW technique was selected for decision-making (*cf.* section II.3.2.3, sub-section Decision rules):

$$\varphi_i = \sum_j u_{ij}\, w'_j \tag{2}$$

where:

φ_i : aggregated score of alternative i;

$i \in$ {North Norfolk; Great Yarmouth; King's Lynn and West Norfolk; Breckland, Area 1; Area 2}

u_{ij} : standardised performance of alternative i on criterion j;

$j \in$ {A.1; A.2; A.3; B.1; B.2; B.3; D.1; D.2; D.3; D.4}

w'_j : standardised weight of criterion j.

To compare performances measured in different units, they must be standardised; the linear scale transformation score range procedure was used to standardise performances (Malczewski, 1999a):

For benefit type criteria: $$u_{ij} = \frac{x_{ij} - \min_j\{x_{ij}\}}{\max_j\{x_{ij}\} - \min_j\{x_{ij}\}} \tag{3}$$

For cost type criteria: $$u_{ij} = \frac{\max_j\{x_{ij}\} - x_{ij}}{\max_j\{x_{ij}\} - \min_j\{x_{ij}\}} \tag{4}$$

where:

x_{ij} : performance of alternative i on criterion j;

$\max_j \{x_{ij}\}$: best performance on criterion of type benefit;

$\min_j \{x_{ij}\}$: best performance on criterion of type cost (i.e. minimum value).

Standardised performances range between 0 and 1. The worst performance on any criterion has a standardised performance of 0; the best performance has a standardised performance of 1; the others vary between 0 and 1. This consistency across criterion simplifies the interpretation of performances.

Criteria weights were standardised using:

$$w'_j = \frac{w_j}{\sum_j w_j} \tag{5}$$

where:

w_j: weight of criterion j.

Table IV.18 displays the standardised performances on the criteria, the standardised criteria weights and each alternative's aggregated score calculated using SAW. The higher the aggregated score, the more preferable the alternative is for the DM. Hence, Area 1 (highlighted in the table) is the recommended case study area. In comparison with its rivals, Area 1 performs particularly well on criteria A.1 – Feasible area and A.3 – Awareness of the topic, Figure IV.9.

Alternatives	A.1 Feasible area	A.2 Developers' interest	A.3 Awareness of the topic	B.1 Potential participants	B.2 Onshore experience	B.3 Offshore experience	C.1 Total area	C.2 No. of LPA	C.3 Urban population	C.4 LPA' concern	Alternative aggregated score
	Evaluation Criteria – Standardised values										
North Norfolk	0.31	0.33	0.00	0.12	0.00	0.60	0.39	0.75	0.00	0.00	0.23
Great Yarmouth	0.00	0.67	0.00	0.00	1.00	1.00	1.00	0.75	1.00	0.00	0.47
King's Lynn and West Norfolk	0.75	0.00	0.50	0.71	0.00	0.60	0.00	1.00	0.33	0.50	0.49
Breckland	0.11	0.67	0.75	0.49	1.00	0.00	0.16	1.00	0.33	1.00	0.54
Area 1	1.00	1.00	1.00	1.00	1.00	0.60	0.05	0.50	0.42	0.67	0.73
Area 2	0.08	1.00	0.00	0.66	1.00	1.00	0.72	0.00	0.63	0.00	0.41
Standardised weights	0.156	0.047	0.125	0.094	0.078	0.063	0.078	0.109	0.141	0.109	1.000

Table IV.18 - Standardised data and alternatives' aggregated scores.

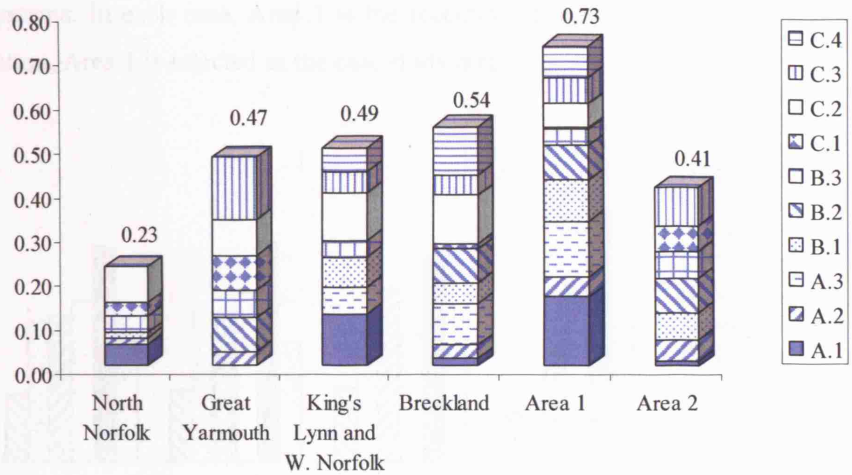


Figure IV.9 - Breakdown of each alternative's aggregated score.

IV.5.4.6. Sensitivity analysis

The robustness of the recommended decision can be evaluated by varying the criteria weights. Three different sets of criteria weights were experimented with, Table IV.19.

	Evaluation Criteria									
Set of weights	A.1 Feasible area	A.2 Developers' interest	A.3 Awareness of the topic	B.1 Potential participants	B.2 Onshore experience	B.3 Offshore experience	C.1 Total area	C.2 No. of LPA	C.3 Urban populatio	C.4 LPA' concern
Original weights	100	30	80	60	50	40	50	70	90	70
Alternative weights - 1	100	50	70	20	50	50	20	80	90	70
Alternative weights - 2	100	0	0	100	0	0	50	50	75	25
Alternative weights - 3	100	100	0	100	0	0	0	0	50	100

Table IV.19 – Set of criteria weights experimented during sensitivity analysis.

The first alternative weighting system is relatively similar to the original and could be interpreted as reflecting some indecisiveness (or uncertainty) about the importance of each criterion. The other two weighting systems were designed to challenge the robustness of the recommended solution. The first of these systems translates a position by someone who thinks that previous knowledge/experience from the public with respect to wind energy is not a relevant factor for decision-making, nor is previous interest by wind energy developers in the area. The second represents a position that can be described as "no matter the workload involved, a good study area is where feasible sites for wind farms exist, developers are interested in it, LPAs are concerned with such developments and potential participants in strategic planning live there".

Figure IV.10 shows the aggregated score computed using the SAW technique for all four weighting systems. In each case, Area 1 is the recommended alternative. Since it is a robust recommendation, Area 1 is selected as the case study area.

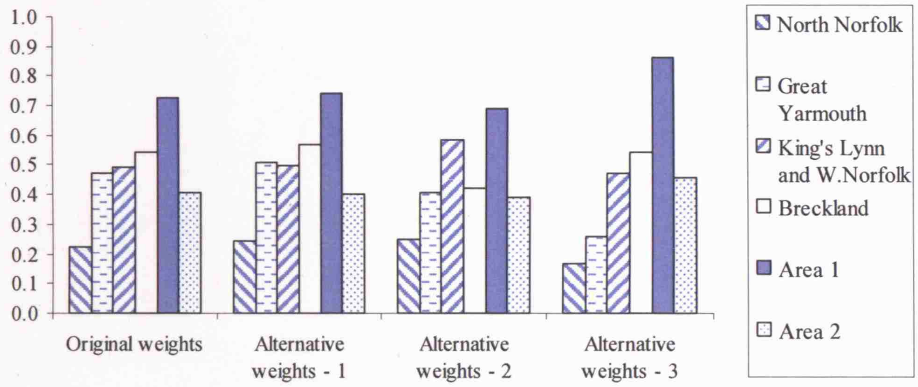


Figure IV.10 – Aggregated scores of alternatives considering alternative sets of criteria weights.

IV.6. Summary

This chapter focuses on the case study selected for implementing a prototype of the proposed framework. Various reasons support this choice. First, wind energy development is a pertinent and controversial topic; hence, it is potentially appealing for the public to engage in the planning process. Second, there is some misinformation on the topic due to "exploitation" of real situations and concepts transmitted by pressure groups and the media; hence a learning-enhancing system seems opportune. Third, poor approval rates of wind farm planning applications have led to recognition that public involvement in the planning process is crucial to reduce opposition to the technology.

More specifically, the selected application is planning wind farm locations at a strategic level. This choice resulted from an identified opportunity to facilitate and support the role that public bodies have been undertaking at this level, which has been rather passive partially due to limited resources available. However, public bodies, in general, recognise that the involvement of the public in early stages of the planning procedure, namely at strategic level, contributes to minimising unfruitful investments by wind energy developers.

Following the identification of the case study and the introduction of the context in which it takes form, the case study area is identified. This is located in the East of England, in the county of Norfolk, extends over approximately 1,453 km^2 and crosses three LPAs' territories: King's Lynn and West Norfolk, North Norfolk and Breckland. The process of determining the case study area is described in some detail because it was specifically tailored to the purpose and constitutes an unusual approach to selecting a case study area. Typically, some type of commitment/convenience dictates the study area to use (Simão and Haklay, 2005).

Chapter V

Prototype development

V.1. Introduction

The previous chapter introduced the spatial (and environmental) planning problem, selected to be at the core of the prototype to be developed, and the case study area. Having in mind these choices, and building on the requirements identified for a prototype implementing the proposed conceptual framework (*cf.* chapter III), this chapter develops the application to implement.

First, the structure chosen for the prototype is outlined. Then, each module (or tier as it will be called) is addressed individually: design options are identified and aspects relevant for its implementation described. The logical model and the structural design behind each module are also presented. Finally, the overarching elements of the system are tackled: the "bundling" of the tiers, navigation within the system, registration and login. The chapter ends with a recapitulation of the most important aspects presented throughout.

V.2. Structure for the prototype

The proposed conceptual framework comprises three modules: 'Background information', 'SDSS' and 'AM' (*cf.* Figure II.5). To implement the prototype, a correspondence was made between each module and a tier in the system. A fourth tier was also planned to fulfil the use case 'Evaluate the system' (*cf.* section III.2.4). Thus, the prototype will comprise four tiers, which will need to be integrated. The application is named WePWEP – Web-based Participatory

Wind Energy Planning - after the selected case study and the environment chosen for its implementation.

V.3. First tier: information area

V.3.1. Content overview

WePWEP's first tier was conceived of as an information area. By studying the selected spatial problem, and the context from which it takes form, several topics were identified with interest to be addressed in the information area. Table V.1 lists these topics, grouped in three main domains: wind energy, wind farm siting and wind energy in Norfolk (the county containing the study area). The information compiled under each topic is available in Simão (2006a,b).

Wind energy	Wind farm siting	Wind energy in Norfolk
Facts and figures	A feasible site	Wind energy target
Why wind energy?	The planning application process	Wind farm projects[1] in the county of Norfolk
The debate around wind energy	Public involvement in wind farm planning	Ecotech wind farm: planning application process
Public opinion on wind energy	Learn more	Swaffham II wind farm: planning application process
Learn more		Learn more

[1] currently operating, approved but still in the pipeline and refused

Table V.1 – Topics and titles of the information to be included in the first tier.

V.3.2. Structural design

Structurally, the information area was conceived of as a web portal; that is, with an entrance webpage that lists all the topics covered and provides direct access to the webpages where they are addressed (Figure V.1). This structure permits flexibility and ease of navigation, two requirements identified for this tier.

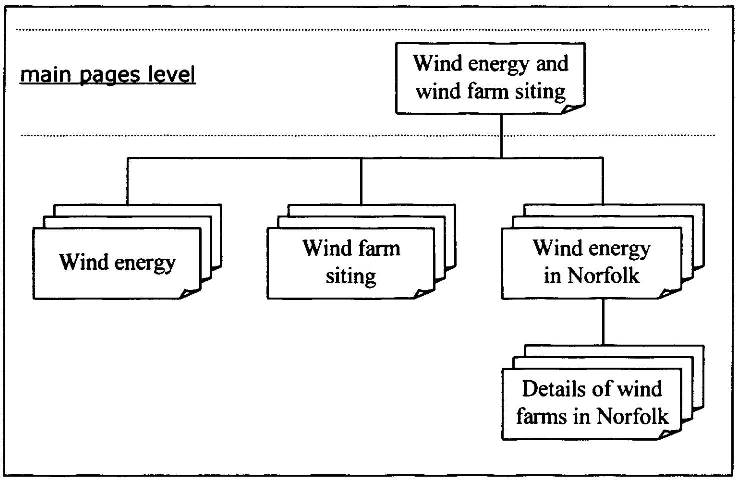


Figure V.1 – Structural design of WePWEP's first tier.

V.4. Second tier: SDSS

WePWEP's second tier is an SDSS. As discussed in section III.2.2, the implementation of this tier requires the spatial problem to be formulated and structured in such a way that it can be tackled using MCDM methodology (*cf.* section II.3.2.3).

The literature contains scarce references to public participation in wind farm siting at the strategic level (the selected planning problem) and none structures the problem in the manner required for this research. Consequently, before presenting the logical model and structural design that support this tier's implementation, the various phases of problem structuring are described, as well as the techniques chosen to elicit the DM's preferences with regard to decision-making and to recommend a decision.

V.4.1. Structuring the problem

In section IV.4.3 the selected planning problem was formulated as "where to locate wind farms?". A systematisation of this formulation, that is compatible with both a MCDM approach and the envisaged use cases for the SDSS and is adequate for the intended users of the system, is as follow:

- technically feasible and economically suitable sites for a wind farm are introduced to the user of the system; the former are henceforth simply referred to as feasible sites and the latter as participant - users of WePWEP are ultimately participants in the planning process;
- evaluation criteria are presented and explained to the participant and s/he is asked to determine their importance for decision-making (i.e. weight the criteria);
- based on the participant's input, a classification of the feasible sites is generated by assigning them to one of three possible classes:
    1. recommended for wind farm siting;
    2. acceptable for wind farm siting; and
    3. unacceptable for wind farm siting;
- the generated classification is displayed and the participant is granted the opportunity to explore it and generate a new classification by revising the submitted criteria weights.

Over the following sections, the selected planning problem takes shape and gains the intended format. More specifically, the feasible sites (corresponding to the decision alternatives) are identified, the evaluation criteria are introduced and operationalised, and the performances of the former on the latter are assessed/estimated.

V.4.1.1. Identifying the feasible sites

Feasible sites for wind farms have already been identified (*cf.* section IV.5.4.3, operationalisation of criterion A.1). The methodology employed to select these sites was refined and re-executed, the driver being the need for greater accuracy. Indeed, if the confidence of WePWEP's users is to be gained, trustworthy information must be provided. Working with the selected study area, which is smaller than the original area, means that the previously set of identified constraints can be developed in more detail and more accurate datasets used.

Methodology

Figure V.2 outlines the methodology followed to identify feasible sites. Existing literature and wind energy professionals were the main resources.

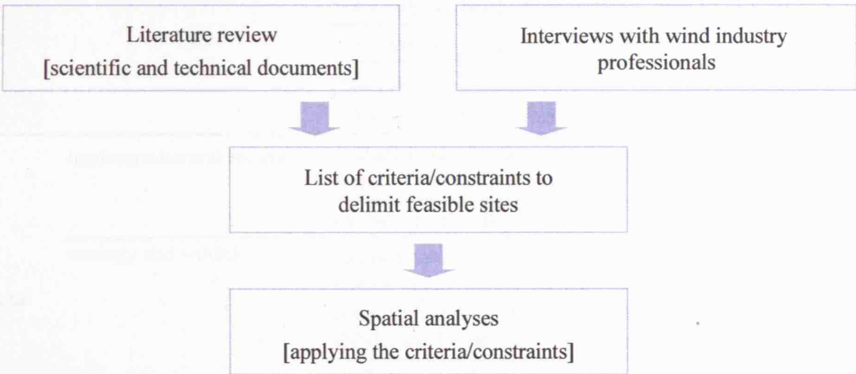


Figure V.2 – Methodology applied to identify feasible sites for wind farms.

Literature reviewed at this stage was essentially the same as that examined earlier (*cf.* section IV.5.4.3). A few additions include policies and advice produced by national bodies to protect the public interest from the negative impacts of wind farms (e.g. The Countryside Agency (CA) and The British Horse Society (BHS)).

A first list of criteria/constraints (more detailed than that assembled previously) was compiled based on the literature. For each aspect, the most permissive constraint for the developer was adopted. This position ensures that the worse-case scenario is brought to public discussion, so it minimises the risk of a wind farm being proposed for a site not considered.

The first list of constraints was subsequently refined through contacts with wind energy professionals. Two companies with local knowledge were approached: NPower Renewables (telephone interview with Ms. V. Portwain on 18th January 2005) and Ecotricity (telephone interview with Mr. D. Graham on 26th January 2005). Both companies stressed the importance of visits to the candidate sites (identified by applying the set of constraints available in the literature) to assess the actual feasibility (and costs) of installing a wind farm there – e.g., to make sure that lorries carrying parts of wind turbines can reach the site.

List of constraints to identify feasible sites

Table V.2 shows the list of criteria/constraints used to identify feasible sites for wind farms.

Considerations	Factors	Constraints
Physical	wind speed	wind speed ≥ 6.5 m/s
	topography	terrain slope < 10%
	land cover	> 500 m from woodlands
Amenities	residential areas	> 500 m from dwellings
	communication axes	> 100 m from roads
		> 100 m from railways
		> 100 m from power lines
	recreational areas	> 100 m from rivers
		> 100 m from canals
		> 100 m from lakes
		> 4 x turbines height from walking trails
		> 3 x turbines height from bridleways
		> 100 m from unclassified county roads and byways
		> 100 m from traffic-free cycling routes
Environmental	landscape/natural beauty	exclude landscape designated areas: Areas of Outstanding National Beauty (AONB) and Norfolk Heritage Coast, National Parks
		exclude: river valleys
	ecology and wildlife	exclude nature conservation designated areas: Special Areas of Conservation (SAC), Special Protection Areas (SPA), Ramsar Sites, Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR) and Local Nature Reserves (LNR)
		exclude: wildlife sites
	ornithology	exclude bird reserves: Important Bird Areas (IBA) and The Royal Society for the Protection of Birds (RSPB) reserves
Historic/cultural	heritage	exclude: Scheduled Monuments and Registered Parks and Gardens
Interferences	physical obstruction	> 17 km from safeguarded civil aerodrome
		> 3 km from aero bases
	electromagnetic interference	> 600 m from TV and radio masts
		> 5 x rotor diameters from existing wind turbines
		visibility analyses from radars' location (RAF - Royal Air Force's and MoD - Ministry of Defence's)

Table V.2 – Criteria for identifying feasible sites for wind farms.

Applying the list of constraints: a GIS-based procedure

GISs have been successfully used to identify feasible sites for wind farms (Baban and Parry, 2001; Hillring and Krieg, 1998; Kidner *et al.*, 1999; Monteiro, 1996; Power, 2004; Sparkes and Kidner; 1996). The following paragraphs report on the GIS-based procedure conducted to obtain feasible sites. The procedure is driven by the derived list of constraints (*cf.* Figure V.2) and was undertaken using ArcGIS Desktop software (version 9.1) by Environmental Systems Research Institute (ESRI).

Data collection

Data collection proved particularly time consuming in this project due to the number of local and national authorities that had to be approached with data requests. Table V.3 (next page) specifies the datasets used for carrying out the required spatial analyses.

Some datasets, such as the locations of Royal Air Force (RAF) and Ministry of Defence (MoD) radars and recently installed wind turbines, did not exist. These were produced from scratch: information on radar stations and wind turbines in the case study area was sought and their locations determined (postcode addresses for radar stations and map coordinates for the position of wind turbines); these locations were then digitised on a map to create the necessary layers of information.

For security reasons, the layout of electricity power lines was not made available. The associated constraint was disregarded due to the complexity involved in generating this dataset.

Data preparation

Some datasets needed preparation before usage. The wind speed dataset required the most laborious preparation. The DTI wind speed dataset consists of a unique ASCII file containing the annual average wind speed data for every 1 km grid square of Great Britain. Data referring to the study area needed to be extracted from this file and converted to a format that the ArcGIS software could interpret and represent spatially.

The OS MasterMap® dataset, consisting of numerous files containing very detailed information, also needed preparation to simplify its manipulation. All files were imported into a relational database (Oracle 10g - Enterprise Edition, managed via ArcSDE 9.1), using a tool called Map Manager (version 8) (Weaver and Whitehead, 2002), so that thematic layers (e.g. buildings, roads and railway) could be easily created via a single ArcSDE command (*create_view*).

Choice of wind turbines

A few constraints in Table V.2 depend on the size (from ground to the blade tip) of the wind turbine. For example, wind turbines should be located at least four turbine's height from walking trails (a recommendation by CA) and three turbine's height from bridleways (as recommended by BHS). To apply these constraints a turbine's height needed to be assumed. A study by Land Use Consultants (LUC) (2003) suggests that wind turbines of 1.5 or 2.0 MW are the most appropriate (efficient) for an area that includes the study area. The tallest turbine discussed in that study is the one with 1.5 MW of capacity, which has total height of 114 m: 78 m hub height and rotor diameter of 72 m; this turbine has been adopted as reference for this

Considerations	Factors	Constraints	Dataset	Information layer	Provider
Physical	wind speed	wind speed ≥ 6.5 m/s	DTI wind speed database		DTI website
	topography	terrain slope < 10%	Land-Form PROFILE™		OS via EDINA Digimap
	land cover	> 500 m from woodlands	Meridian™ 2	Description = Woodland boundary	" " " "
			MasterMap®	DescriptiveGroup = Nature Environment (some types)	OS
			Ancient Woodland		English Nature via Magic website
Amenities	residential areas	> 500 m from dwellings/buildings	MasterMap®	DescriptiveGroup = Buildings	OS
	communication axes	> 100 m from roads	MasterMap®	DescriptiveGroup = Road Or Track	" "
				DescriptiveGroup = Roadside	
		> 100 m from railways	MasterMap®	DescriptiveGroup = Rail	" "
		> 100 m from power lines	No dataset was obtained - the local electricity company declined the provision of requested dataset for security reasons		
	recreational areas	> 100 m from rivers	Meridian™ 2	Description = River small, river medium and river large	OS via EDINA Digimap
		> 100 m from canals	Meridian™ 2	Description = Canal	" " " "
		> 100 m from lakes	Meridian™ 2	Description = Lake	" " " "
		> 4 x turbines height from walking trails	Public Rights of Way	Status = Footpath	Norfolk Council County
			Strategi®	Description = Long Distance Footpath	OS via EDINA Digimap
		> 3 x turbines height from bridleways	Public Rights of Way	Status = Bridleway	Norfolk Council County
		> 100 m from unclassified county roads and byways	Public Rights of Way	Status ≠ Footpath and Bridleway	" " " "
		> 100 m from traffic-free cycling routes	National and regional cycle network		Sustrans
Environmental	landscape/natural beauty	exclude landscape designated areas: Areas of Outstanding National Beauty (AONB) and Norfolk Heritage Coast, National Parks	AONB		Countryside Agency via Magic website
			Heritage Coasts		
			National Parks		
		exclude: river valleys	River valleys		Land Use Consultants
	ecology and wildlife	exclude nature conservation designated areas: Special Areas of Conservation (SAC), Special Protection Areas (SPA), Ramsar Sites, Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR) and Local Nature Reserves (LNR)	SAC, SPA boundaries		English Nature via Magic website
			Ramsar Sites boundaries		
			SSSI boundaries		
			NNR and LNR* boundaries		
		exclude: wildlife sites	Wildlife sites boundaries*		Norfolk County Council
					Breckland District Council
	ornithology	exclude bird reserves: Important Bird Areas (IBA) and The Royal Society for the Protection of Birds (RSPB) reserves	IBA reserves boundaries		RSPB website
			RSPB reserves boundaries		
Historic/cultural	heritage	exclude: Scheduled Monuments and Registered Parks and Gardens	Scheduled Monuments		English Heritage
			Registered Parks and Gardens*		Breckland District Council
Interferences	physical obstruction	> 17 km from safeguarded civil aerodrome	Strategi®	Description = Airport	OS via EDINA Digimap
				Description = Heliport	
		> 3 km from aero bases	Manual digitization on top of OS 1:25 000 Scale Colour Raster		" " " "
	electromagnetic interference	> 600 m from TV and radio masts	Strategi®	Description = Television or Radio Mast	" " " "
		> 5 x rotor diameters from existing wind turbines	Manual digitisation on top of OS 1:10 000 Scale Colour Raster		" " " "
		visibility analyses from Royal Air Force (RAF)'s and Ministry of Defence (MoD)'s radar locations	Manual digitisation on top of OS 1:25 000 Scale Colour Raster		" " " "

* There are differences in datasets supplied by Breckland District Council and other entities

OS - Ordnance Survey

Table V.3 - Datasets used for identifying the feasible areas and respective source.

project. Note that chosing the highest wind turbine is compatible with the safeguarding position introduced earlier (*cf.* section V.4.1.1, sub-section Methodology).

Data processing

Applying the identified criteria/constraints involves spatial analyses (*cf.* Figure V.2). Figure V.3 illustrates the type of analyses involved. The example refers to the "extraction" of sites that verify some physical and amenities constraints from Table V.2. Blue oval forms represent initial datasets, yellow squares represent processes (operations), and green oval forms represent the outputs of processes.

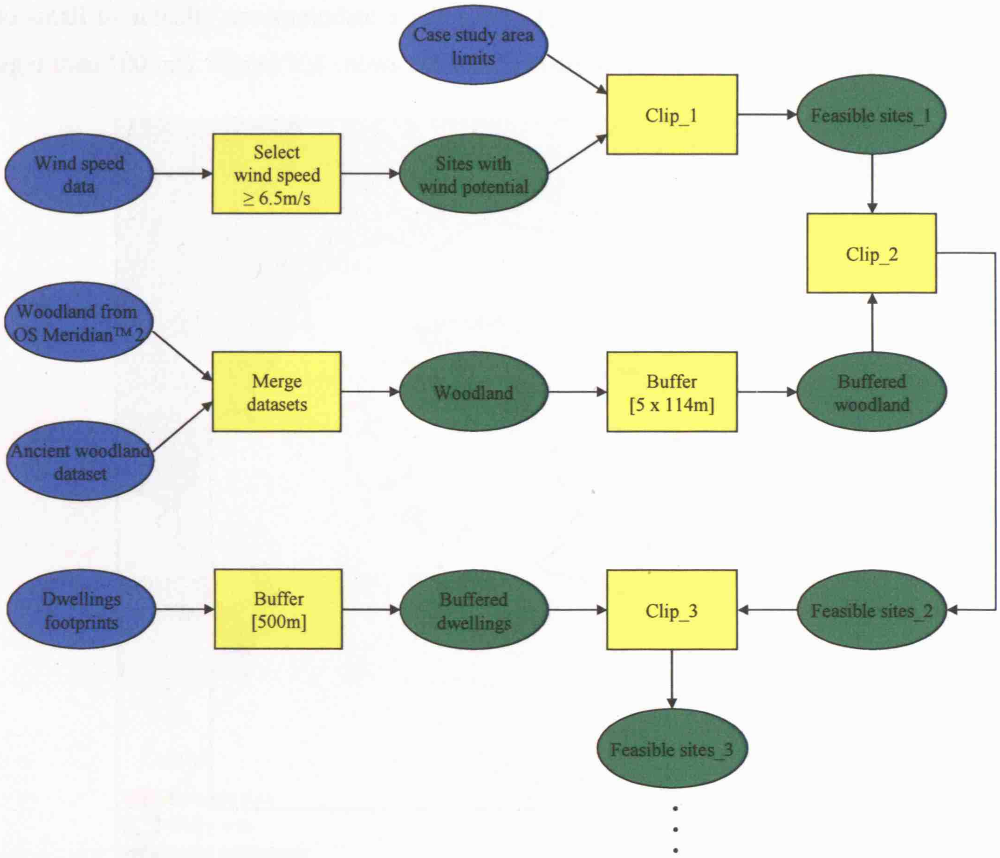


Figure V.3– Illustration of the "sieving" process to identify feasible sites.

ArcGIS software, used to accomplish the spatial analysis, includes a series of pre-programmed functions that render these analyses relatively straight forward. Nevertheless, in some cases these functions could not be completed, namely when thematic layers prepared from OS MasterMap® datasets (e.g. dwellings footprints and road sections) were involved. This was due to the great number of entities contained in these layers.

To work around this obstacle, scripts were written in VBA (the ArcGIS's intrinsic programming language) to execute these functions in batches of a hundred entities.

The total time spent in carrying out all the analyses was very significant. Some analyses took over six hours to complete (these were left running overnight). In total, over one month was spent in data processing, including the time to prepare the scripts.

Results: technically feasible sites for wind farm siting

The "sieving" process identified 204 feasible sites for wind farms, totalling approximately 25.6 km^2. The largest site was 1.77 km^2 and the smallest less than 1 m^2. All sites (six) smaller than 100 m^2 were disregarded either because they were considered "noise" from the analysis or too small to actually accommodate a wind farm (commercial wind turbines have foundations larger than 100 m^2). Figure V.4 shows the spatial distribution of the feasible sites.

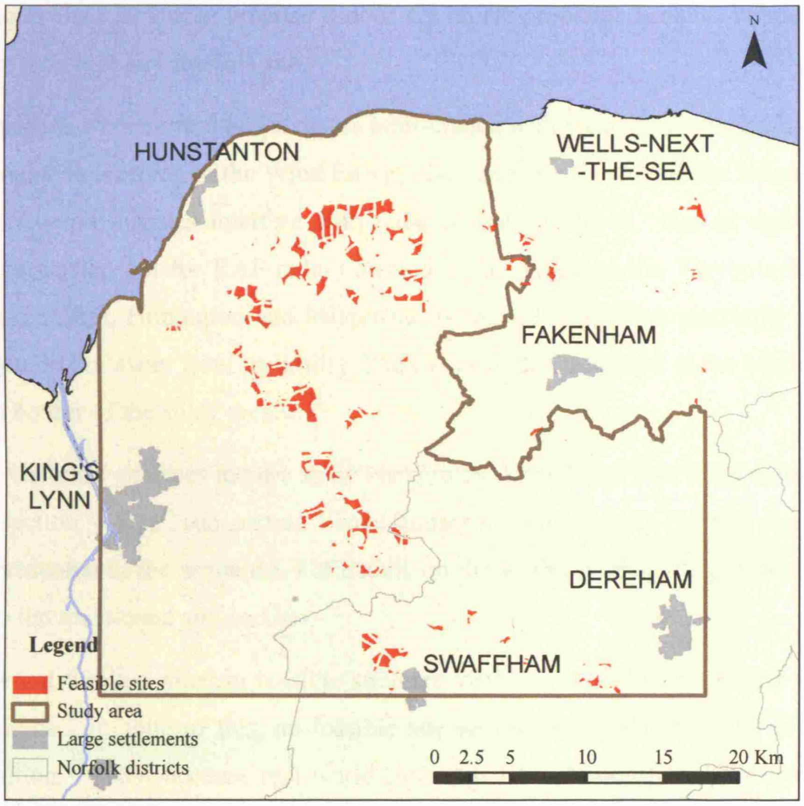


Figure V.4 – Spatial distribution of feasible sites for wind farms.

It should be noted that two constraints from Table V.2 have not been applied thus far: that regarding the terrain slope (<10%); and that concerning electromagnetic interference by radars. The former will be considered at the site scale, when positioning fictitious wind turbines (*cf.* section V.4.1.3, sub-section Step one: positioning fictitious wind turbines); the latter is addressed in the following section.

Notes on the electromagnetic interference constraint

Operating wind turbines produce an electromagnetic field that interferes with civil and military radars. The two most basic effects are: (1) the presentation of false radar responses (known as returns); and (2) the masking of returns from low-flying aircraft (BWEA, 2006; Wind Energy, Defence and Civil Aviation Interests Working Group, 2002). Norfolk is home to many radars and this is an acknowledged hindrance to wind energy development in the area. For this reason, particular attention was dedicated to this aspect.

There are two important civil aviation sites in Norfolk: Norwich International Airport and the Great Yarmouth – North Denes heliport. Safeguarding requirements extend to a maximum of 30 km from these sites (Wind Energy, Defence and Civil Aviation Interests Working Group, 2002). The heliport is located further than 30 km away from any feasible site, so it does not pose problems. The airport is located approximately 27 km away from the closest feasible site. Although closer than 30 km, in practice it does not create problems because its radar vectoring area does not intercept any feasible site.

Visibility analyses were carried out to assess interference with weather or ground-based military air-defence radar. According to the Wind Energy, Defence and Civil Aviation Interests Working Group (2002), wind turbines interfere with radar if they are in its "line of sight". Visibility analyses were carried out for RAF radars located at the Trimingham, Weybourne, Coltishall, Marham, Lakenheath, Honington and Mildenhall bases, all in relative proximity to the study area (less than 30 km away from its limits). The closest radar is located at the Marham base, on the southern border of the study area.

Conducting visibility analyses require some background knowledge that is introduced in a later section (*cf.* section V.4.1.3, sub-section Visual impact-related criteria). For this reason, only the results are presented in the sequence. For details on the visibility analysis procedure the reader is referred to the mentioned sub-section.

Almost all wind turbines sited in feasible sites are visible from RAF radars and would affect their performance. In spite of this, no feasible site was rejected as technically inadequate for wind farm siting. Firstly, because real-world situations have demonstrated that potential radar interference is not a strict reason to reject a wind farm site. In fact, examples prove that wind farm projects have came to fruition in sites initially objected to by the MoD (e.g. Swaffham II wind turbine in Breckland district). Secondly, because radars can be modified to ensure that safety is maintained in the presence of wind turbine farms (Butler and Johnson, 2003). Thirdly, because the design of wind turbines and the siting layout can be optimised to minimise the effects of wind turbines on radar systems (Poupart, 2003).

V.4.1.2. Developing the evaluation criteria

With the decision alternatives identified, the next stage is to define evaluation criteria (*cf.* section II.3.2.3) that will support comparison amongst the alternatives from a specific point of view. Various factors may influence a person's acceptability of a wind farm in a certain location: value placed on the landscape, its social and historical context; value attached to landscape preservation; value given to clean production of electricity; familiarity with wind energy technology and the alternatives, etc. Evaluation criteria should reflect these factors.

To ensure completeness of the criteria set, stakeholders (including the public) should be involved in the identification process. A number of techniques involve laypeople in this process, for example, Participatory Rural Appraisal approaches (The World Bank, 1996). Unfortunately, to be implemented effectively these techniques require a great deal of time and human resources. Limitations on both resources forced the adoption of a swifter approach.

Methodology

Figure V.5 outlines the methodology adopted to identify the evaluation criteria. It is based on examination of relevant literature and a small number of "in-depth interviews" with key interveners in the wind farm siting process.

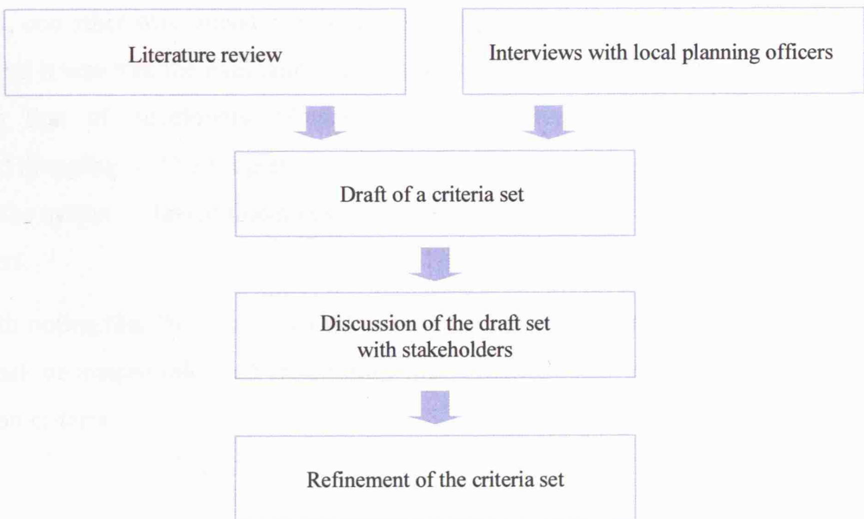


Figure V.5 – Methodology followed to identify evaluation criteria to classify feasible sites into suitability classes.

The literature contains several references to MCDM methodology applied to wind farm siting (Cavallaro and Ciraolo, 2005; Monteiro *et al.*, 2001; Ramírez-Rosado *et al.*, 2005). The evaluation criteria used in these studies, however, were not made completely explicit, in particular with respect to the way they have been operationalised. For this reason a new set of evaluation criteria was developed.

In addition to the literature, campaign documents (most coming from wind energy objectors) and wind farm planning application processes were also reviewed and local planning officers interviewed (Mr. D. Glason from Great Yarmouth Borough Council on 19th October 2004 and Mr. S. Faulkner from Norfolk County Council on 1st November 2004). Listening to and analysing real-world cases helped to consolidate ideas regarding the wind farm/energy issues that raise public concern and grasp their real significance.

A first set of evaluation criteria was compiled and subsequently "verified" and refined in consultation with (other) key stakeholders. Friends of the Earth, Greenpeace, English Heritage (EH), EN, CA, RSPB and LPAs with jurisdiction in the study area were approached to discuss the developed set of criteria. Unfortunately, not many of these contacts came to fruition[24]. Contributions were gained from King's Lynn and West Norfolk Council's planning policy manager, Mr. P. Jermany (interviewed on 23rd February 2005) and Breckland Council's principal planning officer, Ms. A. Long (interviewed on 2nd March 2005).

The evaluation criteria

Figure V.6 shows the final set of nineteen evaluation criteria that account for the potential impacts of a wind farm on people and the environment (mainly in its surroundings), and the characteristics of the site where it is to be installed. In addition to the five major factors identified, one other was considered but later disregarded: development costs. The argument for considering it was that the evaluation criteria set should embrace all stakeholders' perspectives, including that of developers. However, both planning officers (contacted stakeholders) suggested dropping it. Their argument was that from the public's point of view – the most likely users of the system - development costs are not a relevant criterion; it is uniquely a concern of developers.

It is worth noting that the criteria set was derived using five desirable properties: completeness, operational, decomposable; non-redundancy and minimum size (*cf.* section II.3.2.3, sub-section Evaluation criteria).

[24] Available funding constrained mobility to meet stakeholders on dates of their convenience and some organisations were unavailable to discuss the criteria set.

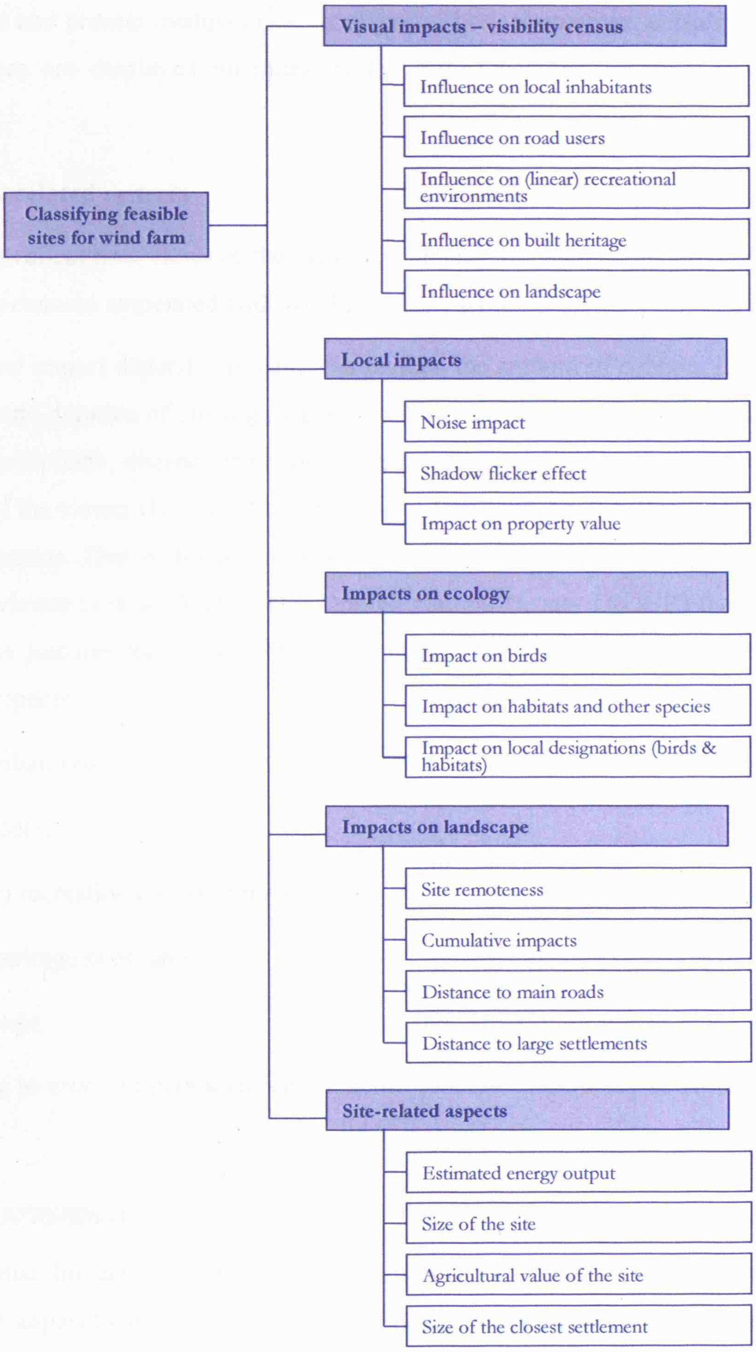


Figure V.6 – Set of evaluation criteria to assign feasible sites to suitability classes.

V.4.1.3. Evaluating performances on criteria

The next step in the problem structuring procedure consists of assessing how the alternatives perform on the evaluation criteria (*cf.* Figure II.2). For that, each criterion needs to be operationalised.

Starting from the visual impacts factor, and following the order in which the criteria are presented in Figure V.6, subsequent sections justify each criterion, describe how it has been operationalised and present evaluations/estimations of how alternatives perform with respect to it. Performances are displayed on maps, called *criterion maps*, identical to those used in WePWEP.

Visual impact-related criteria

Visual impacts reflect how views of the landscape change and their effect on people (LI/IEMA, 2002); a major concern associated with wind farms (*cf.* section IV.2.3).

Perceived visual impact depends on numerous factors: the amount of concern for visual quality, the frequency and duration of viewing, the attitude toward the cause of visual intrusion, viewing conditions (atmospheric, distance from viewpoint, visible proportion ...) and, very importantly, expectations of the viewer (Bishop, 2002; Sheppard, 1989). This last factor is likely related with the viewing context. That is, for a similar view of a wind farm, the perceived impact is likely greater if the viewer is in an Area of Outstanding Natural Beauty (AONB) than if s/he is on a cycleway. This justifies the consideration of various contexts (evaluation criteria) under the factor visual impacts:

- local inhabitants;
- road users;
- (linear) recreational environments;
- built heritage sites; and
- landscape.

Before moving to criteria operationalisation, some consideration of visual impact assessment is due.

Visual impact assessment (VIA)

The term 'Visual Impact Assessment' (VIA) describes a systematic analysis of the possible changes to the appearance of the landscape by a proposal prior to implementation (Macaulay Institute, 1999). The two the most common techniques for VIA are *viewpoint analysis* and *zone of visual influence* (ZVI). In viewpoint analysis, the impact is analysed from key viewpoints using wireframe (or wireline) perspectives and photomontage (*i.e.* computer simulated models of turbines superimposed onto digitised images of the actual site). In ZVI studies, visibility maps of the development site are produced based on *viewshed computation.*

A viewshed identifies all locations in a digital elevation model (DEM) that can be connected by means of an uninterrupted straight line (called "*line of sight*") from a given viewpoint, Figure V.7. If two or more viewpoints need to be considered jointly, individual viewsheds can be overlaid to produce a *cumulative viewshed*; this shows how many viewpoints can be seen from each location, i.e. the visual magnitude (Llobera, 2003), also called the visibility index (Kidner *et al.*, 1997).

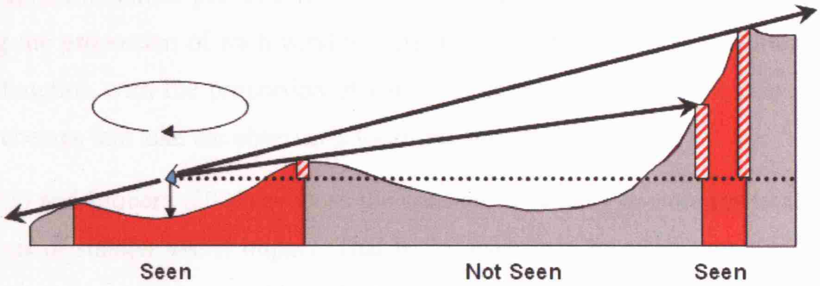


Figure V.7 – Illustration of viewshed computation.

Although the visibility of a site is normally thought of in terms of being viewed from outside its boundaries, most viewshed calculations adopt an outward view based on the principle of intervisibility (Fisher, 1995; Miller *et al.*, 1999).

It should be stressed that viewsheds are by no means accurate (Bishop, 2003). Uncertainty arises from inaccuracies in the computing algorithm and, more significantly, from the DEM (Fisher, 1993, 1995). Furthermore, atmospheric conditions may render an unobstructed object invisible and the observer's ability to resolve features is not considered in the analysis. Gillings and Wheatley (2000) provide a non-technical summary of the problems and risks surrounding the use and interpretations of viewsheds. Cumulative viewsheds are subject to the same limitations as single viewsheds plus the edge effect (Llobera, 2003).

<u>VIA in wind farm planning</u>

Various institutions have published guidelines for wind farm VIA. Perhaps the most relevant are 'Guidelines for Landscape and Visual Impact Assessment' by LI/IEMA (2002) and 'Visual Assessment of Windfarms: Best Practice' compiled by the University of Newcastle (2002) for Scottish Nature Heritage (SNH).

In practice, photomontages and ZVI (i.e. viewshed-based maps) are the most commonly employed techniques for VIA. Viewsheds have been computed from discrete viewpoints (generally identified during field reconnaissance) and centred on the wind turbines' location (Burton *et al.*, 2001; Kidner, 1997; Kidner *et al.*, 1999; Miller *et al.*, 1999). Variations to these techniques have been proposed to improve predicted visual impact levels.

Kidner *et al.* (1997: 201) suggest performing visibility analysis using different base heights at the turbine locations to get a complete picture of the best and the worst case, i.e. the areas from which the entire wind turbines are visible and those where from they are only partly visible. Miller *et al.* (1999) suggest the creation of an index of relative visibility based on this approach.

Kidner *et al.* (1999: 220) suggest using weighting schemes of relevant variables to adapt a viewshed representation to produce scores for visual impact. They propose two schemes: one considering the proportion of each wind turbine that is visible; the other combining a distance weighting function with the proportion of each visible turbine. Moreover, they suggest using weighing schemes that take the observer's location into account.

Fisher (1995) and Llobera (2003) propose the concept of visual exposure (or total viewshed) to identify areas of smaller visual impact. That is, for each map location, compute how visible a wind turbine positioned there would be. This idea had been further developed and implemented in a recent module (WindPLAN) of the well-known WindPRO software package to design and plan wind farm projects. The module supports combining total viewsheds with distance weights, so points further away from wind turbines are given less weight (lower impact) than closer ones; and with a population density dataset, so the sites where turbines will be seen by a smaller number of inhabitants can be identified (Thøgersen *et al.*, 2003).

Despite the improved techniques, various authors have highlighted the limitations of photographic and two-dimensional (2D) mapping techniques to access potential visual impacts from wind farms (e.g. Sparkes and Kidner, 1996). Alternative approaches are based on modern computer visualization techniques such as three-dimensional (3D) models, animations and interactive, virtual reality environments (see, for example, work by Kidner *et al.*, 1999; Miller *et al.*, 2000; Miller *et al.*, 2005; Benson, 2005; Bishop 2002; Bishop and Lange, 2005).

<u>Conducting VIA: adopted methodology</u>

VIA should be based on field reconnaissance to identify significant viewpoints and inventory site-specific details important for the analysis, such as the degree of visibility (partial *versus* total) or the quality of the context (Bergen *et al.*, 1995). The size of the study area, the resources available and the timescale of this project, however, rendered such an approach impracticable and a desktop-based procedure was adopted, Figure V.8.

Fundamentally, this procedure is based on viewshed computation from the wind turbines' locations. Thus, two essential datasets are: the location of wind turbines and the DEM. The first two stages of the methodology correspond to the preparation of these datasets. These and the following stages are addressed in the following paragraphs.

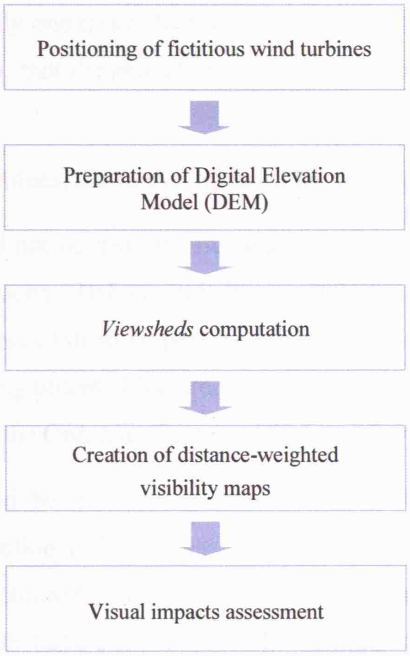


Figure V.8 – Adopted methodology for VIA of a wind farm installed on a feasible site.

Step one: positioning fictitious wind turbines

Recognising that the effect of wind turbines on the landscape is a source of public concern, in 2002, Breckland District Council and the Borough of King's Lynn and West Norfolk commissioned a study to evaluate the capacity of different types of landscape for wind energy development (LUC, 2003). An outcome of this study is a classification of the landscape character types of the area according to their capacity to accommodate various scales of wind energy developments. Four scales of developments were considered: single wind turbines, small-scale wind farms (linear or clustered arrangements of 2 to 12 turbines), medium-scale wind farms (developments of 13 to 24 turbines) and large scale wind farms (over 25 turbines). A summary classification map was produced to depict this classification (LUC, 2003: Figure 6.5).

This map was used to inform the positioning of fictitious wind turbines: feasible sites were allocated fictitious wind turbines in accordance with their capacity to accommodate them.

Since this study does not cover the totality of the study area, to maintain uniformity of procedures across the whole study area, it was decided to reduce the study area to the extent covered by the study. That is, the original study area (Area 1 in Figure IV.8) was reduced to include only the territory administered by two, instead of three, district councils: King's Lynn and West Norfolk and Breckland. In terms of size, this implies a reduction of approximately 21%; the total extent is now 1,144.6 km^2. In terms of feasible sites, 26 identified feasible sites were removed (those falling within North Norfolk district council); and three sites suffered a size reduction, although in only one this reduction was significant (47.5% of its original size). It is important to stress, though, that the reduction of the study area does not affect the goals or processes of this research.

For the placement of wind turbines, the following considerations were borne in mind:

- Wind turbines should not be installed in sites where slope angles are greater than 10% for construction reasons (Baban and Parry, 2001)[25] and to facilitate land cover regeneration after works (steep slopes are more prone to erosion). This criterion was considered by checking potential locations for wind turbines against a background slope map computed using the Ordnance Survey (OS) Land-Form PROFILE™ dataset.
- Wind turbines should be installed in sites with SW-W-NW aspect when the local prevailing wind direction is W-E. This condition ensures that wind turbines benefit from direct and undisturbed wind flow. Like the slope map, a terrain aspect map was computed from the OS Land-Form PROFILE™ dataset: wind turbines were positioned only in sites with an aspect between 225 and 315 degrees.
- Wind turbines should be positioned according to a layout design that maximises compactness and minimises the energy wake effect (i.e. the energy loss due to wind shadowing from upstream turbines). The DWEA (2006) recommends spacing wind turbines between 5 and 9 rotor diameters apart in the prevailing wind direction, and between 3 and 5 diameters apart in the direction perpendicular to the prevailing winds, Figure V.9. Adopting the minimum figures (worse-case scenario), and knowing that the rotor diameter of the selected wind turbines is 72 m (*cf.* section V.4.1.1, sub-section Applying the list of constraints: a GIS-based procedure; Choice of wind turbines), wind turbines should be spaced every 360 m (5 x 72 m) in the prevailing wind direction and 216 m (3 x 72 m) in the perpendicular direction.
- Wind turbines should be positioned at the highest possible altitude and towards the borders of the feasible site. This strategy realises the most unfavourable situation from the public point of view because wind turbines become more conspicuous, yielding greater impacts than if located towards the interior of a feasible site. The adoption of this strategy complies with the principle of bringing into public discussion the most unfavourable cases (*cf.* section V.4.1.1, sub-section Methodology).

[25] Note that the topographic constraint from Table V.2 that has not been applied so far (*cf.* section V.4.1.1, sub-section Results: technically feasible sites for wind farm siting) is applied at this moment.

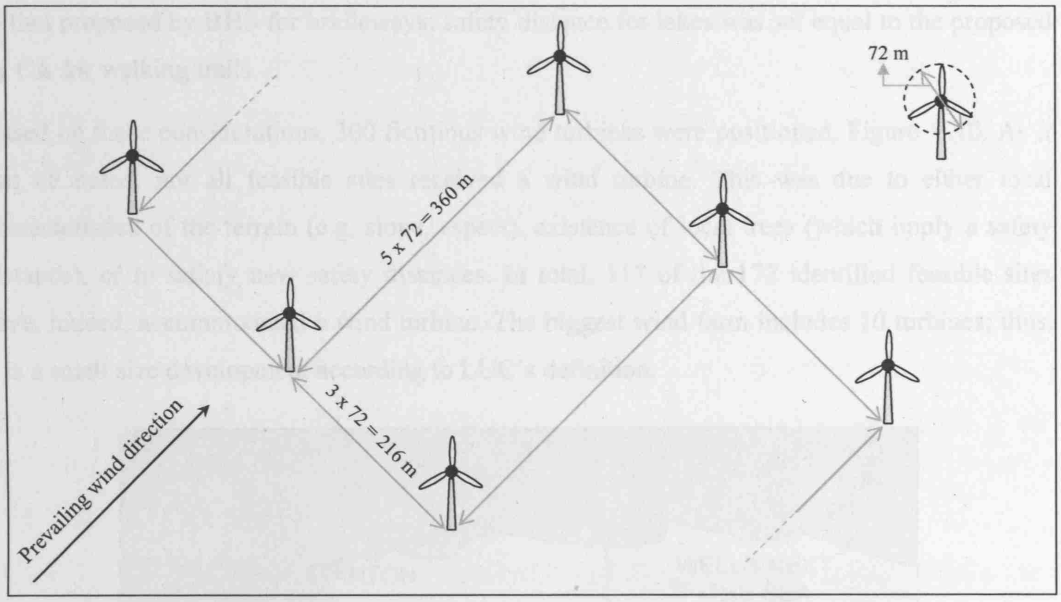


Figure V.9 – Illustration of turbines spacing in a wind farm with a South Westerly prevailing wind direction.

Moreover, the following strategy was followed to position turbines:

- the OS 1:10 000 Scale Colour Raster was used as a backdrop to avoid "installing" wind turbines in locations already occupied by features, such as individual trees, that have not been considered during the process of identifying feasible sites. To avoid wind flow turbulence, a technical separation distance of 1.5 times the turbine's blade tip height was considered between these and trees.
- although, according to the devised list of constraints, wind turbines can be positioned as close as 100 m to roads, railways, canals and other features (*cf.* Table V.2), when positioning the turbines the following safety distances were considered:
  - 171 m from roads, railway, cycling routes and unclassified country roads and byways, corresponding to 1.5 times the turbine's blade tip height (equal to 114 m – *cf.* section V.4.1.1, sub-section Applying the list of constraints: a GIS-based procedure; Choice of wind turbines);
  - 342 m from rivers and canals, corresponding to 3 turbine's blade tip height;
  - 456 m from lakes, corresponding to 4 turbine's blade tip height.

Behind this decision is the fact that wind turbines are currently taller than 100 m, therefore, 100 m safety distance would be insufficient in the case, fortunately unlikely, of a turbine falling down. Therefore, as rationalised by CA, a more sensible approach is to set safety distances dependent on the turbines' blade tip height. Safety distances for rivers and canals were set equal to that proposed by BHS for bridleways; safety distance for lakes was set equal to the proposed by CA for walking trails.

Based on these considerations, 300 fictitious wind turbines were positioned, Figure V.10. As it can be noted, not all feasible sites received a wind turbine. This was due to either local characteristics of the terrain (e.g. slope, aspect), existence of local trees (which imply a safety distance), or to satisfy new safety distances. In total, 117 of the 172 identified feasible sites have, indeed, accommodated a wind turbine. The biggest wind farm includes 10 turbines; thus, it is a small size development according to LUC's definition.

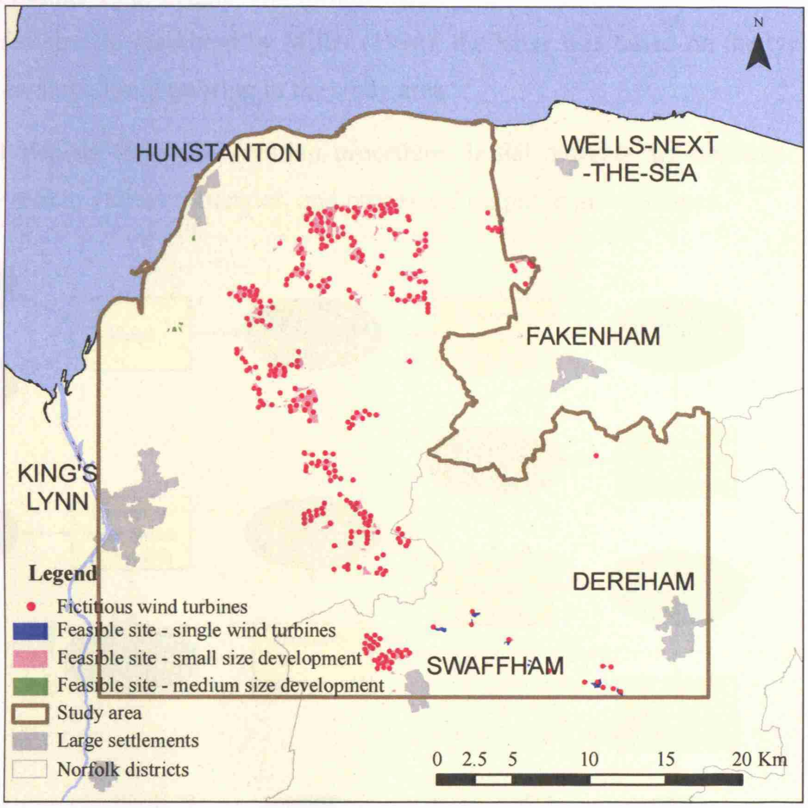


Figure V.10 – Location of fictitious wind turbines.

Step two: preparing the digital elevation model (DEM)

DEMs record a topographical representation of the surface of the Earth at regularly spaced horizontal intervals (i.e. records altitude in a raster digital format)[26]. There are two types of DEMs: digital terrain models (DTMs) and digital surface models (DSMs). While the former represent bare ground, the latter include topographic features such as vegetation, buildings and other man-made structures.

[26] Triangular irregular networks (TIN) could also be used for the same purpose (Llobera, 2003), but are less common.

OS produces DTMs at two different scales (1:10,000 and 1:50,000), available to the academic community through CHEST. For VIA in flat zones (which is the case), the LI/IEMA recommend the use of topographic information at 1:10,000 scale. Moreover, they recommend the use of DSM instead of DTM, as it results in more realistic assessment of how wind turbines are viewed across the landscape (LI/IEMA, 2002: 149).

Since no DSM was available, a procedure was set to convert the highest resolution DTM available, the OS Land-Form PROFILE® 1:10,000 DTM, with 10 m cell resolution, into a DSM by "adding" vegetation and buildings. Vegetation was considered with a characteristic height of 12 m and buildings 10 m height. The former figure was estimated based on the average height of various tree species measured by Miller (1996); the latter was based on the typical 3-storey buildings with sloped roof existing in the study area.

Figure V.11 depicts the DSM creation procedure. Initial datasets are depicted in blue oval forms; processes in yellow rectangles, and processes' output in green shapes.

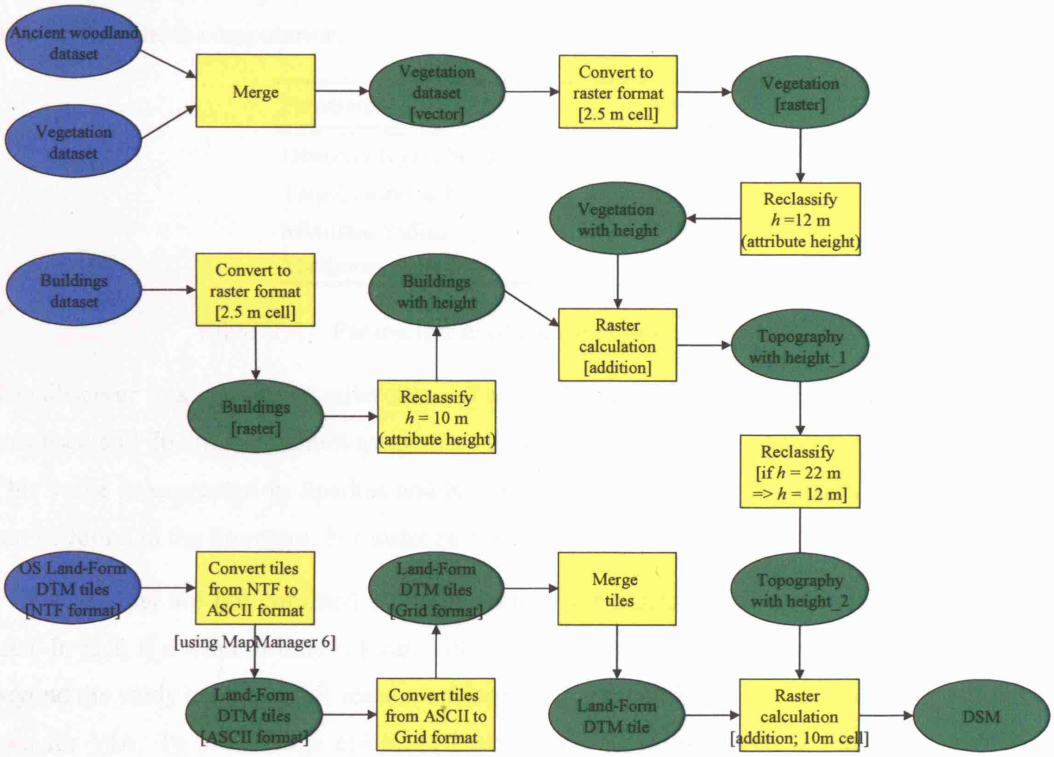


Figure V.11 – DSM creation procedure.

For the study area, the buildings and vegetation datasets were created from the OS MasterMap® dataset[27]. As this dataset was not available for the fringe area (*cf.* next section), OS

[27] The buildings dataset include all features whose Group Description = buildings. The vegetation datasets includes some types of vegetation (Group Description = nature environment), selected for being capable

Meridian™ 2 data was used instead: Developed Land Use Areas (DLUA) were used to replace the buildings dataset and Woodland to replace the vegetation dataset. (Note that being these two datasets in vector format, they had to be converted to raster format – 2.5 m was the selected cell size to keep some detail, however, once combined with the 10 m resolution DTM such detail disappears.) The two DSMs were created separately and eventually combined into a single file using the condition: for all cells where MasterMap®-based DSM is not available, use data from the Meridian™ 2-based DSM.

Step three: viewsheds computation

Once the required datasets were ready, viewsheds were computed. Most contemporary GIS packages are equipped with *viewshed* calculation algorithms. ArcGIS Desktop (version 9.1) provides this functionality through the Spatial Analysis extension.

A cumulative viewshed was computed for each feasible site, considering all fictitious turbines in the site and an observer positioned in every DSM vertex (cell). Table V.4 shows the parameters used in viewsheds computation.

Parameters	Values
Observer (eyes) height	1.7 m
Target (wind turbines) height	114 m
Minimum radius	0 m
Maximum radius	20 km

Table V.4 – Parameters used for running visibility analyses.

The observer was considered taller than 1.7 m, the height of the selected wind turbines (114 m) was used and 20 km the furthest away that visual impacts from a wind turbine can be perceived. This value is suggested in Sparkes and Kidner (1996) and LI/IEMA (2002), but other figures can be found in the literature. For instance, the Scottish Executive (2002) suggests 30 km.

Visual impacts are not confined by "constructed boundaries", such as the limits of the study area. In fact, if a wind turbine is located close enough to the borders, visual impacts will be felt beyond the study area. For this reason, a fringe of 20 km width was considered around the study area for VIA. To avoid edge effects (visual impacts to be estimated in totality), the fringe's width was set equal to the maximum distance where from visual impacts from a wind turbine can be perceived.

Due to the high number of cumulative viewsheds to compute (117 - one for each feasible site), a script was written in VBA to automate the procedure.

of obstructing the view of a person with eye's height of 1.7m. These include rough grassland and scrub (i.e. Description Term = Rough Grassland or Description Term = Scrub).

Step four: weighting visibility with distance

Perception of visual impacts depends on the distance to the intrusion. In the case of wind turbines, the closer the observer is, the stronger is the level of intrusion; hence the greater is the impact. To incorporate this aspect in the VIA, computed viewsheds were combined with classes of distances, within which the level of visual intrusion was considered constant.

Table V.5 shows the classes considered. They were devised based on the effect of distance on perceived visual impact referred in the Scottish Planning Advice Note 45: Renewable Energy Technology (Scottish Executive, 2002: para 78). Each class was given a weight that reflects the perceived visual impact when a wind turbine is seen from the corresponding distance.

Distance from wind turbines	Weight	Normalised weight
Up to 2 km	10	0.50
2-5 km	6	0.30
5-15 km	3	0.15
15-20 km	1	0.05
Total weights	20	1.00

Table V.5 – Weights reflecting the level of visual intrusion of a wind turbine based on distances.

An automated procedure was developed to combine each of the 117 computed viewshed with a distance-weighted raster dataset derived based on Table V.5 - details can be found in Pradhan (2005: 21)[28]. For each feasible site (wind farm), the result consists of a raster dataset showing the terrain cells where a wind turbine is visible from (this implies the principle of intervisibility in viewshed computation – *cf.* sub-section Visual impact assessment above). Each cell stores the distance weight based on the distance to the closest visible turbine (cells where from any wind turbine is visible store a null value).

[28] This reference consists of an MSc thesis developed within the context of this research and supervised by the author.

Pradhan's goal was "to implement a web-based MC-SDSS to allow the public to participate in the decision research process of locating the best feasible sites for wind energy development" (Pradhan, 2005: 10). As Pradhan makes clear in his dissertation, his project "was taken from the section of ongoing PhD research activity of Ana Simao (....)" that "will consist of information and applications divided into four tier system (...). This dissertation project (...) focuses on the 2nd tier of the above system".

In practice, the relationship between Pradhan's thesis and this thesis is as follow: based on methodologies supplied by the author, Pradhan developed the required scripts to automate the assessment of impacts of feasible sites on the various evaluation criteria and sub-criteria; his scripts and results were then used in the development of this thesis. In addition, Pradhan implemented a web-based MC-SDSS application using ArcGIS Server. The author used this system as a departing point to develop WePWEP's second tier.

Step five: assessing visual impacts of wind turbines

Once in custody of the distance-weighted visibility maps, the VIA (i.e. the assessment of performances of alternatives on the evaluation criteria) was initiated. The procedure employed is similar for every criterion (context/receptor) and is depicted in Figure V.12.

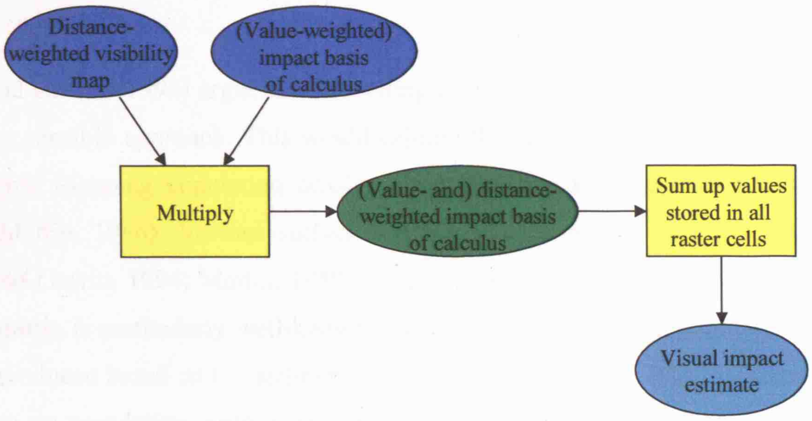


Figure V.12 – Methodology for assessing visual impacts of a wind farm.

The impact basis of calculus is the only dataset that varies. For example, for assessing visual impacts on inhabitants, the impact basis of calculus used was a population density dataset, for assessing visual impacts on road users, the impact basis of calculus used was a weighted road network.

The following sections report on how each evaluation criterion has been operationalised, identify and discuss the assumptions behind the process and present the estimated performances of the alternatives. These will be compiled in the so called decision matrix (*cf.* section II.3.2.3, sub-section Alternatives).

Visual impact on local inhabitants

The sight of a wind turbine can be considered an impact. If so, the suitability of a feasible site to accommodate a wind farm depends (inversely) on the number of local inhabitants that will be able to see the wind farm from their residence.

Kidner *et al.* (1999) suggest that overlaying the wind farm viewshed on a spatial representation of demographic data enables to estimate how many people will be affected by the visual impact of this development. Accordingly, the indicator adopted to operationalise this criterion was the distance-weighted population living in the areas where a wind turbine is visible from.

This indicator suggests that a population density dataset should be used as impact basis of calculus. There are various techniques to produce this dataset. The simplest one is to take population data aggregated by zonal units (e.g. census data) and, assuming that population is uniformly distributed throughout, divide the population per the unit area. Variations to this concept could be implemented, such as assume that the population is concentrated in urban areas (DLUA available from the OS Meridian™ 2 dataset could be used for the purpose). However, this approach is highly criticisable from the theoretical point of view, based on the modifiable areal unit problem (Openshaw, 1984; Unwin, 1996) and ecological fallacy (Robinson, 1950).

Langford and Unwin (1994) argue that modelling census population data in the form of density surfaces is a sensible approach. This would capture the spatial distribution of population over the zonal unit. Mapping population density as continuous surface can be traced back to the seventies (Martin, 1996). Various surface construction techniques have been proposed (e.g. Langford and Unwin, 1994; Martin, 1989; 1996; Okabe and Sadahiro, 1997). In the UK, work by David Martin is particularly well-known due to a series of national population surfaces that have been produced based on the technique that he devised (Martin, 1989; Bracken and Martin, 1995). Since no population surface was available based on Census 2001, the SurfaceBuilder (version 0.1.0) software package (Martin, 2007) was used to create it.

SurfaceBuilder reads X and Y coordinates of a zone centroid location and population data from a text file and generates the population surface using the model proposed in Martin (1989)[29]. This is displayed on the screen and is exportable to ASCII data formats.

Martin *et al.* (2000) suggest using spatially detailed datasets to improve the geographical detail of the resulting population surface. Detailed 2001 census counts are released at OA level. The authors recommend associating OA with postcode units and reallocating OA census counts to these in proportion to the known household (domestic delivery) count at each postcode. This was the procedure employed. The association between OA and postcode units was accomplished based on the OA boundaries and OS Code-Point® datasets (the latter provides the geographical location for each postcode unit). All postcode units whose Code-Point Location Coordinate fell within an OA were associated to this OA. As no perfect match exits between OA and unit postcode boundaries, an error (difficult to quantity) is associated to population estimates: people living in a certain OA (and censused there) may have been considered as living in a neighbour OA if the Code-Point Location Coordinate of the respective unit postcode fell within the neighbour OA[30].

[29] Developments of the earlier modelling technique, such as preserving population counts in zonal units (Martin, 1996), have not yet been implemented in the used version of the SurfaceBuilder package.

[30] A way round this problem was possible assuming that domestic delivery points are evenly distributed throughout each postcode unit and then estimating the number of domestic delivery points within each OA. Such procedure was not, nevertheless, carried out because resulting benefits were judged marginal.

Table V.6 specifies the input data and modelling parameters used in SurfaceBuilder. The Cressman model with a uniform decline (decay parameter equals to one) is the software's default. It is used to shape the population decay with distance from the unit postcode centroid to the kernel edge (outwards). The output cell size and initial kernel distance used were recommended by the software's author (Martin, 2005).

Input data	
X, Y coordinates	Code Point Location Coordinates from OS Code-Point®
Population data	Population estimates (2001) for unit postcode locations

Modelling parameters	Values
Decay function	Cressman model
Decay parameter	1
Initial kernel width	250 m
Output cell size	50 m x 50 m

Table V.6 – SurfaceBuilder's input data and modelling parameters to produce a population density surface.

The ASCII file exported from SurfaceBuilder was imported into ArcGIS to obtain the population density surface. A visual comparison between this and the OS 1:50,000 Colour Raster dataset of the area revealed matching patterns between the estimated population distribution and built-up areas.

With the impact basis of calculus prepared, the VIA was initiated (*cf.* Figure V.12). This procedure needed to be executed 117 times, one for each wind farm. To automate this procedure, scripts were written (see Pradhan (2005) for details). Obtained estimates of visual impact on local inhabitants were subsequently standardised[31] to facilitate comparison. These are represented in Figure V.13. Darker sites are less suitable for wind farm accommodation, for they have associated greater visual impact on local inhabitants.

It seems relevant to note that only resident population (census data) has been considered in this analysis. The inexistence of systematic information on visitor population (especially second homers) did not make possible a more accurate approach.

[31] The standardisation procedure is described in section IV.5.4.5, formulae (3) or (4), respectively for benefit and cost type of criterion.

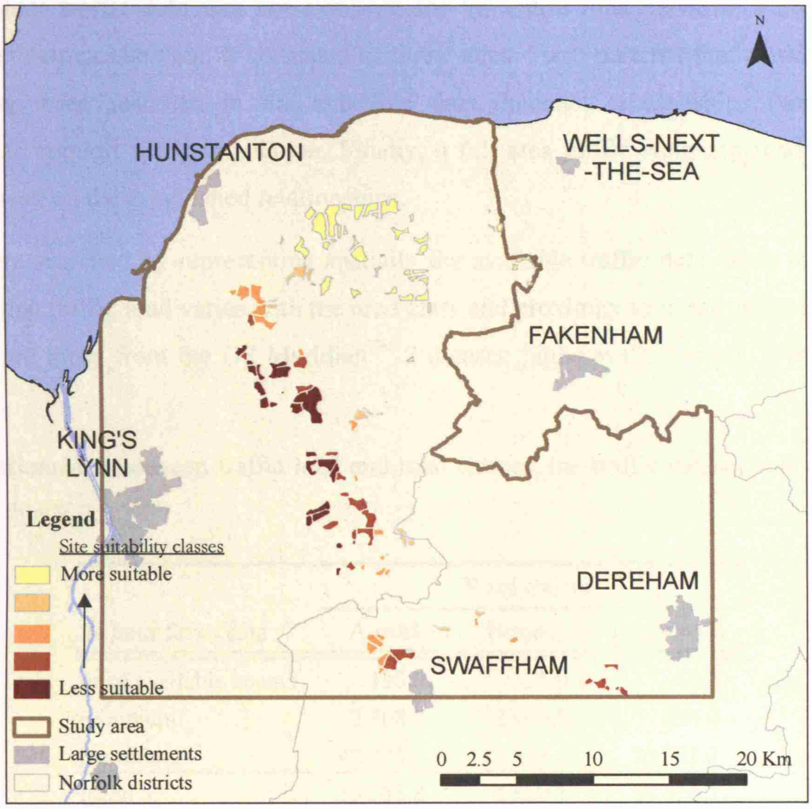


Figure V.13 – Standardised performance of feasible sites on the criterion visual impact on local inhabitants.

Visual impact on road users

Sun-strobe or flashing effect from blades can be prevented by coating the blades with a non-reflective paint or covering. Nevertheless, rotating blades can be found distracting and/or disturbing by drivers and passengers travelling by. If this is the case, the suitability of a feasible site to accommodate a wind farm would depend (inversely) on the number of road users affected.

The indicator adopted to operationalise this criterion was the aggregated length of road segments where from a wind turbine is visible, weighted by road traffic and distance to the closest visible wind turbine. Road length is taken as a proxy to the duration of perceived visual impact. The assumption behind is that the journey of each vehicle is along the all road where from a wind turbine is visible.

A traffic-weighted road dataset was selected for impact basis of calculus (*cf.* Figure V.12). This dataset was produced based on the road network layout extracted from the OS Meridian™ 2 dataset and traffic data obtained from NCC, on behalf of Department for Transport. Acquired traffic data reported to 2003 and consisted of 24 hours flows measured at some points (road sections). Since traffic data was not available for the entire road network, a procedure was developed to extrapolate data. It consisted of three steps. First, patterns that could be used for extrapolating were searched in the available data. Second, relationships (weights) were established to support the extrapolation. Finally, a full area traffic-weighted road dataset was produced based on the established relationships.

Patterns were searched by representing spatially the available traffic data. Such representation made clear that traffic load varies with the road class and proximity to urban areas. Road classes considered are those from the OS Meridian™ 2 dataset: highways[32], A-road, B-road or minor road.

To find relationships between traffic load and road classes, the traffic dataset was examined as shown in Table V.7.

	Road classes		
24 hour flows data	A-road	B-road	minor road
nr of available counts	190.0	21.0	68.0
minimum	2 708.0	2 000.0	294.0
maximum	42 096.0	12 584.0	25 391.0
mean	15 085.8	4 869.1	4 956.3
standard deviation	8 626.3	2 784.0	5 672.5

Table V.7 – Descriptive statistics on traffic data acquired from Department for Transport.

There is great variability (standard deviation) on the traffic counts within each class. However, if the mean is taken as an approximation to the daily traffic load in each road class, it is possible to say that traffic in minor roads is comparable to traffic on B-roads, whereas traffic in A-roads is approximately triple that amount. Based on these findings, relative traffic weights were derived for road classes, Table V.8.

Road class	Traffic weight
A- road	3
B-road	1
Minor road	1

Table V.8 – Relative road traffic by road classes.

According to these weights, one kilometre of A-road, falling within a visible area from a wind farm, is worth three kilometres of B-road or minor road; because, in average, traffic on A-roads in three times more intense than on B- or minor roads.

[32] There are not highways crossing the study area or the 20 km-width fringe.

The spatial representation of the traffic data also showed that traffic is more intense near the main urban areas and on road A47, linking King's Lynn to Norwich. To embed this pattern into the traffic-weighted road dataset to be produced, a strategy was set.

- Interpolate traffic data using an inverse distance weighted function (over maximum distance of 2.5 km) to make explicit traffic patterns; and
- Draw concentric circles, centred in the principal urban areas, to capture the increase traffic load as one approaches the urban centre; based on these circles, an "extra weight" weighting scheme was created and combined with that of Table V.8 to translate the extra traffic load in those areas.

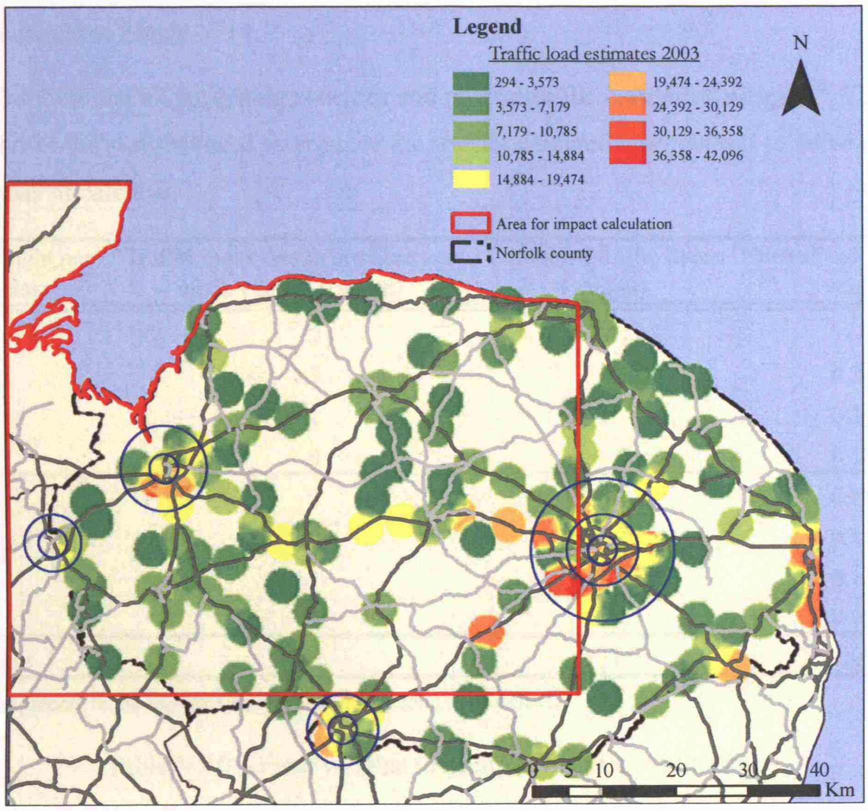


Figure V.14 – Interpolated traffic data.

Table V.9 shows the radius of the circles drawn and the extra weight assigned to roads segments falling within them. Apart Norwich, the capital of the East of England region, for which three circles were created, all other urban areas were encircled only by two circles, Figure V.14.

	Inner circle		Middle circle		Outer circle	
	radius (km)	extra weight	radius (km)	extra weight	radius (km)	extra weight
Norwich	2	2	5	1.5	10	1
King's Lynn	2	1.5	--	--	6	1
Thetford	2	1.5	--	--	5	1
Wisbech	2	1.5	--	--	4	1

Table V.9 – Relative road traffic in the proximity of urban centres.

- Assign an extra weight (1 point) to the main corridor between King's Lynn and Norwich (A47) to account for the more intense traffic there than in other roads of the same class, Figure V.14.
- Combine the all weighting schemes and normalise the combined weights[33]. Table V.10 shows the weights used to produce the traffic-weighted road dataset to serve as impact basis of calculus.

Traffic weight per road class	Traffic index due to proximity to urban centres (weight)	Combined traffic index (weight)	Normalised combined weight
3	2	5*	--
	1.5	4.5	0.26
	1	4	0.24
	0	3	0.18
1	2	3	0.18
	1.5	2.5	0.15
	1	2	0.12
	0	1	0.06
Total weight		17	1.00

* No road segments in the impact area was found to belong to this class.

Table V.10 – Final weights to estimate relative road traffic.

For each feasible site, visual impact on road users were then assessed using a similar procedure to that implemented to estimate visual impacts upon local inhabitants (based on the presented methodology, developed by the author, Pradhan develop the scripts – details are available in Pradhan (2005: 26). Figure V.15 depicts the standardised performance of each alternative on the criterion. Darker sites are less suitable for wind farm accommodation, for they are associated to greater visual impacts on road users.

[33] The normalising procedure is described in section IV.5.4.5, formulae (5).

It is worth noting that, although the criterion translates impact on road users, only the number of vehicles was accounted for. This implies that all vehicles transport the same number of people – an approximation forced by the unavailability of detailed data. A second aspect is that the developed weighting scheme, based on traffic loads (meaning the more traffic, the more people affected by the visibility of wind turbines - *cf.* Table V.10), ignores the possibility that people travelling on minor roads might be more susceptible to visual impacts because they may be more attentive to the landscape. This aspect is tackled by criterion 'Proximity to main roads' under the factor 'Impacts on the landscape'.

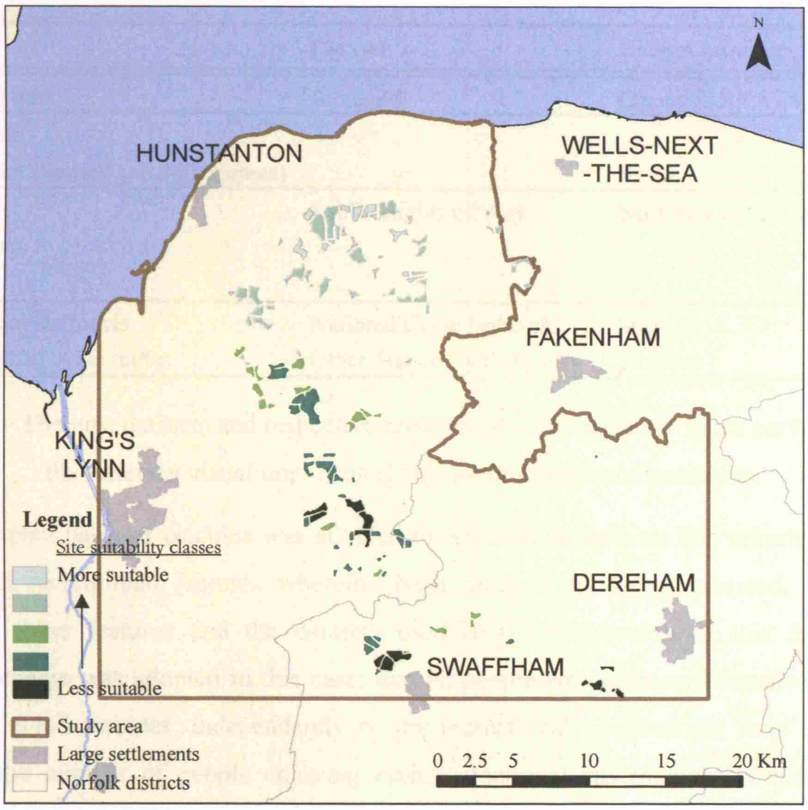


Figure V.15 – Standardised performance of feasible sites on the criterion visual impact on road users.

Visual impact on (linear) recreational environments

Recreational environments are defined as areas or facilities where people go to enjoy the nature and the landscape. At these locations, people might feel affected by the visibility of wind turbines. This criterion accounts for this possibility. Feasible sites are considered as more suitable for accommodating a wind farm as lesser is the visual impacts on (people enjoying) the recreational environments.

As indicated in Table V.11, only linear recreational environments were considered for this criterion operationalisation. "Spot-type" environments (picnic sites and viewpoints) were initially considered, but difficulties in combining the visual impacts assessed on these with that assessed on linear environments led to disregard the former. “Area-type” environments, such as designated sites for nature conservation purposes and landscape protection, are considered under a different criterion (*cf.* next sub-section).

The indicator adopted to operationalise this criterion is the aggregated distance-weighted length of the linear recreational environments where a wind turbine is visible from. Length is taken as a proxy for the duration of the perceived visual impact; the same idea behind the estimation of visual impacts on road users (*cf.* previous sub-section).

Theme	Dataset	Dataset provider
National trail	Strategi®	OS via EDINA Digimap
Picnic site Viewpoint (limited and 360 degrees)		
Footpath Bridleway Byway	Public Rights of Way	Norfolk County Council
National cycle routes	National Cycle Network	Sustrans
Other signed cycle routes	Other Signed Cycle Routes	Sustrans

Table V.11 – Themes, datasets and respective provider of data used to estimate performances on the criterion visual impact on (linear) recreational environments.

A simple impact basis of calculus was adopted to estimate impacts on this criterion: a dataset including all recreational features wherein visual impacts are being assessed. Table V.11 summarises these features and the datasets used in the preparation of this dataset[34]. No weighting scheme was adopted in this case; that is, people are considered equally affected by the sight of wind turbines, independently of the recreational environment were they are in. Moreover, the number of people enjoying each recreational environment is assumed to be similar (in average, per time period) - a constraint enforced by the lack of information on the number of people that use each recreational environment.

Impact performances on the criterion were evaluated in a similar manner to the previous criteria; Pradhan produced the scripts to automate the process - details are available at Pradhan (2005: 27). Figure V.16 depicts the standardised performances on the criterion. Darker sites represent less suitable sites for accommodating a wind farm, as they imply greater visual impacts on users of recreational facilities.

[34] Paths along canals, rivers and lakes are included in the public rights of way dataset. Waterways (i.e. navigational routes along coast) were considered coincident to walkways along the coast, included in the public rights of way dataset.

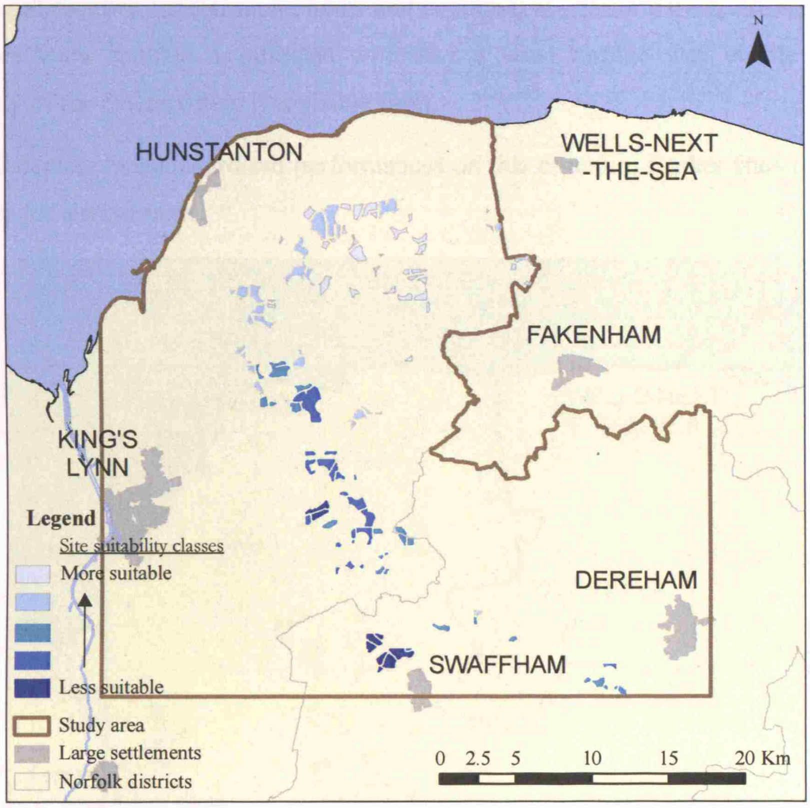


Figure V.16 - Standardised performance of feasible sites on the criterion visual impact on (linear) recreational environments.

Visual impact on built heritage

Visitors of historic and cultural sites may feel affected by the sight of wind turbines. This criterion takes this possibility into account when deciding on the suitability of feasible sites to accommodate a wind farm. Greater visual impact is associated to lesser suitability for wind farm siting.

The indicator adopted to operationalise this criterion is the distance-weighted number of built heritage sites where a wind turbine is visible from. The selected impact basis of calculus (*cf.* Figure V.12) is similar to that used in the previous criterion and consists of a dataset integrating all built heritage features. This dataset includes listed buildings, schedule monuments and registered parks and gardens (thematic datasets obtained from EH) and also historic parkland (e.g. historic settings and other built-up sites with special architecture or historic character) as provided by Breckland Council.

Similarly to the previous criterion, no weighting system was considered to differentiate amongst built heritage features with regard to the importance of perceived visual impact and the number of visitors. As the impact basis of calculus contains both "point-type" (listed buildings) and "polygon-type" features (parks, monuments and settings), for performances estimate, polygon-type features were counted as affected whenever a wind turbine was visible from there, irrespectively of the extent where it is visible from.

Figure V.17 depicts the standardised performances on this criterion. Darker sites represent less suitable sites for a wind farm.

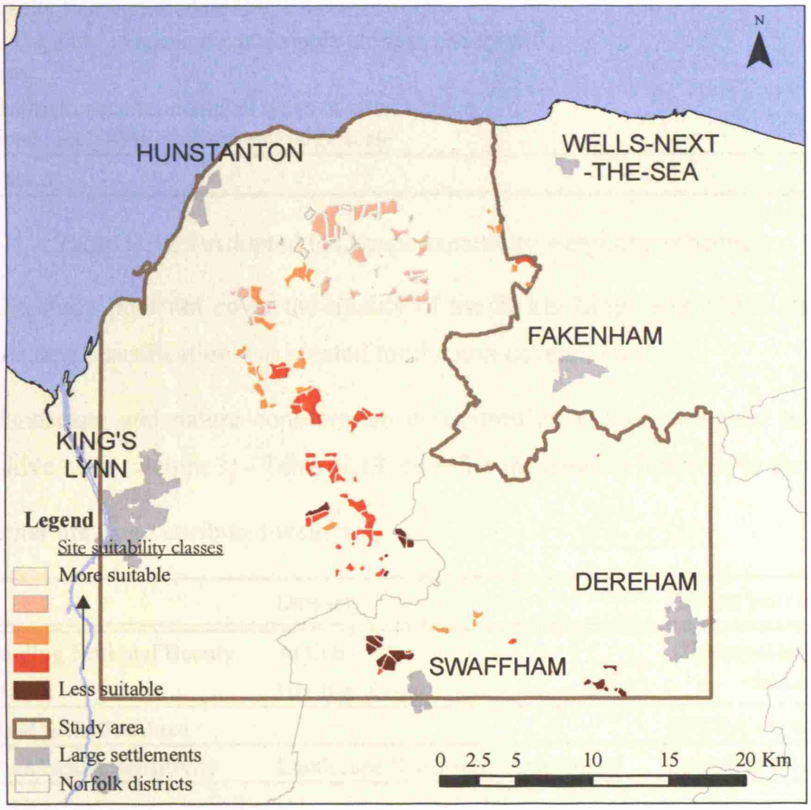


Figure V.17 - Standardised performance of feasible sites on the criterion visual impact on built heritage.

Visual impact on landscape

Aesthetics of wind turbines and their impact on landscape are a major public concern and a factor determining opposition to wind energy development (*cf.* section IV.2.3 Public attitude to wind energy); hence, the relevance of this criterion for decision-making on sites suitability to accommodate a wind farm.

Performances on this criterion were estimated by the extent of "sensitive landscape areas" where a wind turbine is visible from, weighted by its quality/sensitivity and the distance to the closest visible wind turbine. The adopted impact basis of calculus consists of a landscape dataset, weighted by quality/sensitivity. To produce this dataset the sensitivity classification of the landscape proposed in LUC (2003) was used and the weighting scheme of Table V.12 devised.

LUC (2003)'s classification of landscape sensitivity	Sensitivity index (weight)	Normalised weight
Very high: Limited capacity for any form of turbine development	3	0.50
High: Capacity to accommodate single turbines only	2	0.33
Moderate: Capacity to accommodate single turbines and small scale groups	1	0.17
Low: Capacity to accommodate all types of wind turbine developments, including medium and large scale	0	0.00
Total weight	6	1.00

Table V.12 – Adopted landscape sensitivity weighting scheme.

As the LUC's study does not cover the totality of the 20 km fringe around the study area, an expedite landscape classification was created for the non-covered area:

- all landscape and nature conservation designated areas were assigned to the highest sensitive class (weight 3) - Table V.13 identifies the datasets involved in this class;
- all other areas are attributed weight 1.

Theme	Dataset	Dataset provider
Area Outstanding National Beauty	AONB	Countryside Agency via MAGIC
Heritage Coast	Heritage Coast	
Environmental Sensitive Area		DEFRA via MAGIC
Classes of Landscape Sensitivity	Landscape Sensitivity Assessment	Land Use Consultants
Ramsar Sites		
SPA		
SAC		Countryside Agency via MAGIC
National Nature Reserve		
SSSI		
Local Nature Reserve		

Table V.13 – Designated areas and respective dataset provider used to create a sensitivity weighting scheme for the area not covered by LUC (2003)'s study.

Impact performances on this criterion were evaluated in a similar manner to the previous ones (Pradhan developed the necessary scripts – details available at Pradhan (2005: 28)). Figure V.18 depicts the standardised performances on it. Darker sites represent less suitable sites for accommodating a wind farm for they imply greater visual impact on landscape.

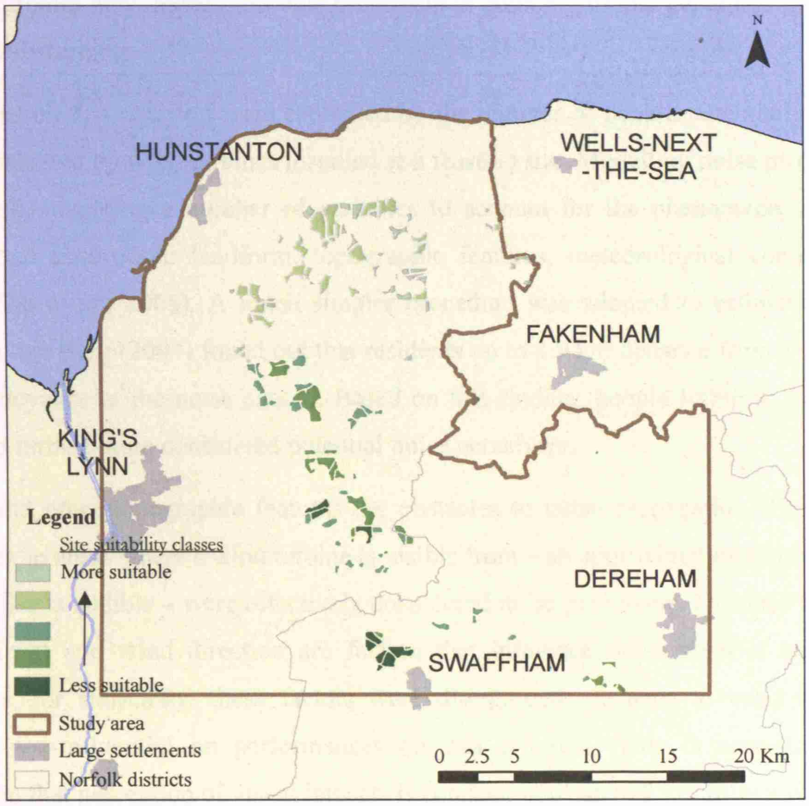


Figure V.18 – Standardised performance of feasible sites on the criterion visual impact on landscape.

Local impact-related criteria

Three local impacts associated to wind farms are likely relevant for assessing the suitability of feasible sites to accommodate wind turbines:

- noise impact;
- impact due to the shadow flicker effect; and
- impact on property value.

The following sections address each of these criteria individually, describing how they were operationalised and presenting the alternatives' estimated performances on them.

Noise Impact

Despite the wind industry's assertion that modern wind turbines are much quieter than in the past and the various documents reassuring that turbines noise has no biological health effects (see BWEA (2005) for an overview on the topic), noise may be considered a relevant factor when deciding on the suitability of feasible sites to accommodate a wind farm. It is so as noise from wind turbines may, indeed, become prominent in quiet nights and generated low frequency noise can be disturbing.

Performances on this criterion were estimated by the number of people potentially affected by the noise generated by wind turbines installed at a feasible site. Modelling noise propagation is a complex task, involving a number of variables to account for the phenomena of reflection, deflection and absorption: landform, topographic features, meteorological conditions, wind direction (Zhu *et al.*, 2005). A much simpler procedure was adopted to estimate local noise impact. van den Berg (2004) found out that residents up to 1.9 km distance from a wind turbine can feel annoyance at the noise caused. Based on this finding, people living in a 2 km radius from a wind turbine were considered potential noise perceivers.

Buildings and other topographic features are obstacles to noise propagation. Therefore, only people living in areas where a wind turbine is visible from – an approximation to places wherein turbines' noise is audible – were effectively considered noise perceivers. Distance to the source (wind turbines) and wind direction are factors that influence noise level at each location. Despite this, for simplicity, these factors were disregarded: distance to wind turbines was considered non-influential on performances on this criterion. This is consistent with the consideration that perception of visual impacts is constant until up to 2 km from a wind farm (*cf.* Table V.5).

Performances were estimated by applying a similar procedure to that employed to estimate visual impact on local inhabitants. The difference was that only residents within 2 km from a wind turbine were counted. Details on the procedure can be found in Pradhan (2005: 30), who prepared the scripts to assess the impact based on the methodology developed by the author. Figure V.19 shows standardised performances on the criterion. Darker sites are less suitable for accommodating a wind farm; they imply a larger number of people affect by the turbines' noise.

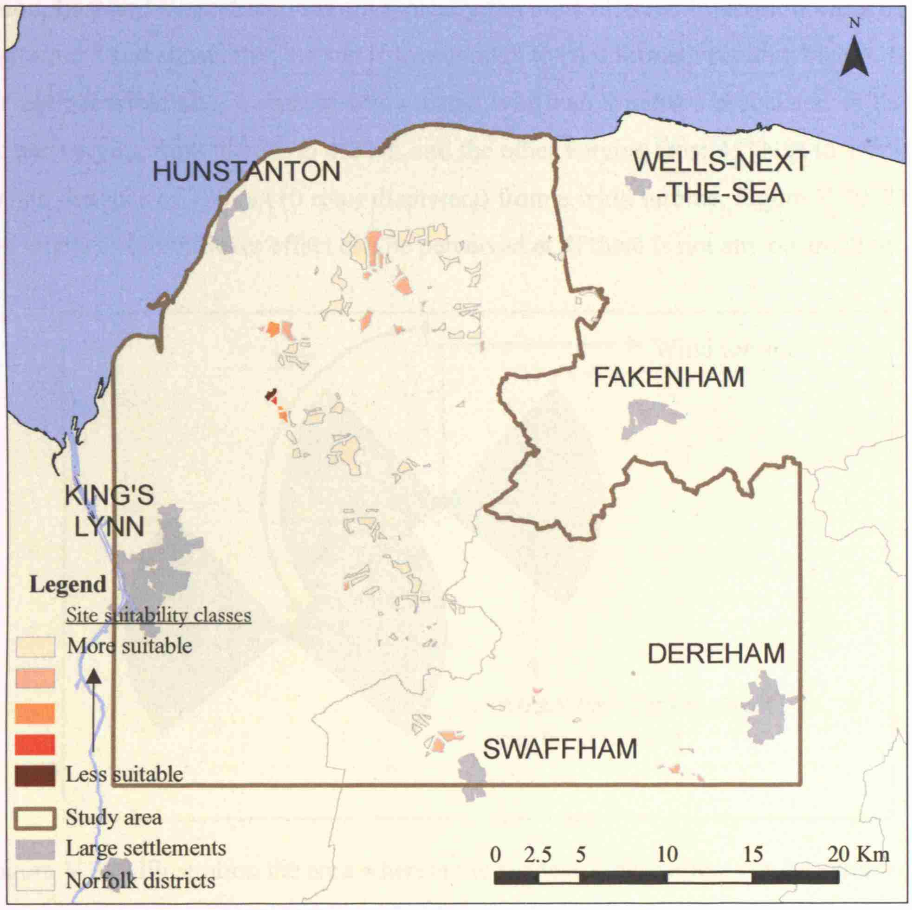


Figure V.19 – Standardised performances of feasible sites on the criterion noise impact upon local inhabitants.

Impact due to the shadow flicker effect

Under certain combinations of geographical position and time of day, the sun passing behind the rotating blades of a wind turbine casts a shadow that flicks on and off. This is known as shadow flicker effect and may cause annoyance to neighbouring residents. This criterion takes this impact into account for decision-making on the sites' suitability to accommodate a wind farm.

The indicator selected to estimate performances on this criterion is the number of residents in areas where shadow flicker can be perceived and a wind turbine is visible from. Areas where wind turbines are visible from have already been computed; areas where the shadow flicker effect can be perceived were determined based on the following indications (ODPM, 2004):

- at the UK latitudes, only properties within 130 degrees either side of north relative to the turbines can be affected; and
- flicker effects only occur within ten rotor diameters of a turbine.

In addition, East and West directions are typically the most affected by shadow casts because it is during sunrise and sunset that the sun is low enough to pass through rotating blades. Based on this, for each feasible site, a dataset was created with two windows associated to each wind turbine: one varying from 40° SE to 45° NE and the other varying from 45° NW to 40° SW, with a maximum distance of 720 m (10 rotor diameters) from a wind turbine, Figure V.20. These are the areas where shadow flicker effect can be perceived at, if there is not any obstruction.

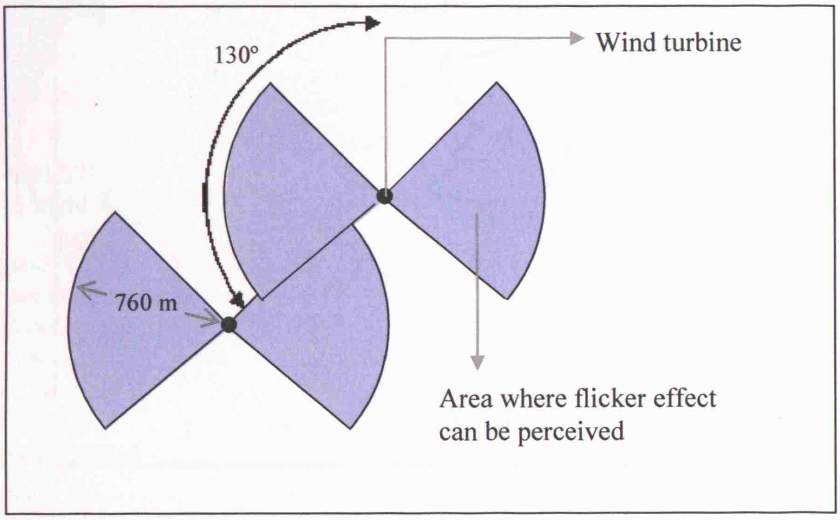


Figure V.20 –Illustration the area wherein the shadow flicker effect can be perceived, considering a wind farm with two turbines.

To consider obstructions, these datasets were combined with the already computed viewshed of the respective wind farm. Finally, based on the population density surface, performances on this criterion were estimated. Figure V.21 shows the standardised performances on the criterion. Less suitable sites for accommodating a wind farm are depicted in darker colours. If a wind farm is installed in those sites, a larger number of people is potentially affected by the shadow flicker effect, when compared to a wind farm located in sites depicted in lighter colours.

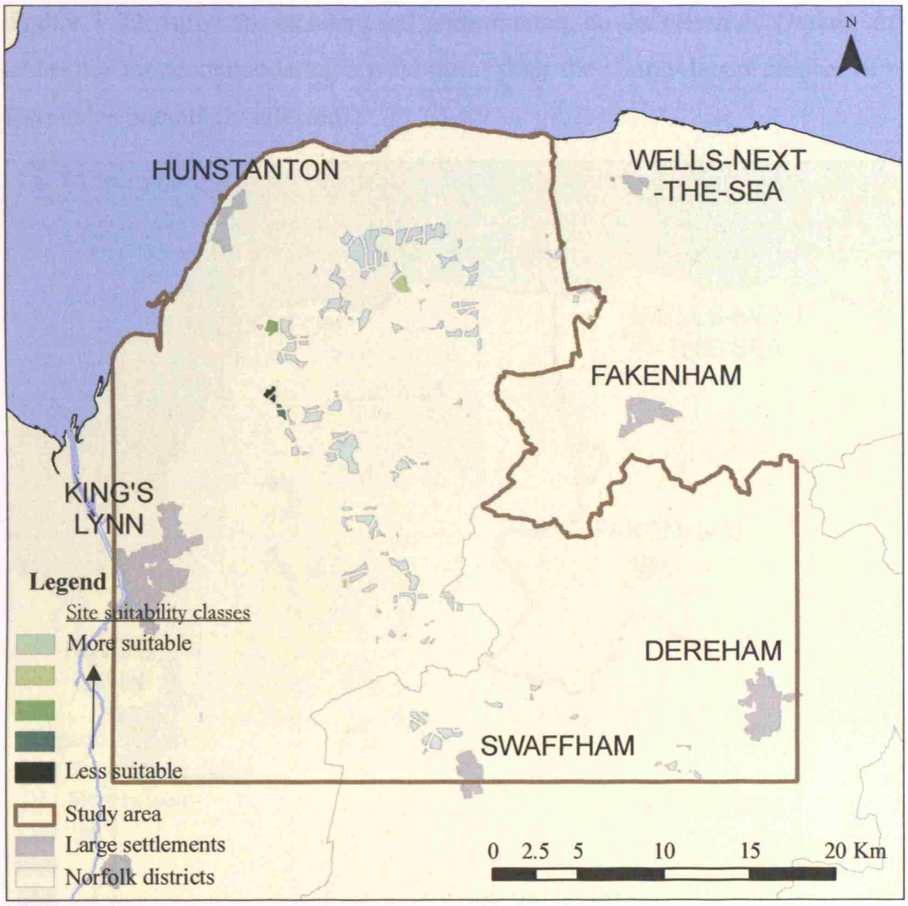


Figure V.21 – Standardised performances of feasible sites on the criterion shadow flicker effect upon local inhabitants.

Impact on property value

Fears of property devaluation are often associated with proximity to wind farms, mostly due to the visibility of wind turbines. Such concerns suggest that impact on property value can be a relevant criterion to assess the suitability of a feasible site to accommodate a wind farm.

It was considered that only properties where wind turbines are visible from may have their value affected, based on assumption it is their visibility that affects property value. It was also considered that properties further away than 2 km from a wind turbine would not have their value affected. Accordingly, the indicator adopted to operationalise this criterion was the number of buildings where from a wind turbine is visible, within a 2 km radius from them. In reality, the number of dwellings should be counted, as one building can include more than one dwelling. However, the information available did not allow this level of accuracy.

The OS MasterMap®'s buildings layer was used as the impact basis of calculus. As this dataset was only available for the study area, impacted buildings outside this area were not account for. Pradhan developed the scripts to compute impacts on this criterion; see Pradhan (2005: 30) for details. Figure V.22 shows the standardised performances on the criterion. Darker sites depict less suitable sites for accommodating a wind farm, since they imply larger number of buildings having their value potentially affected.

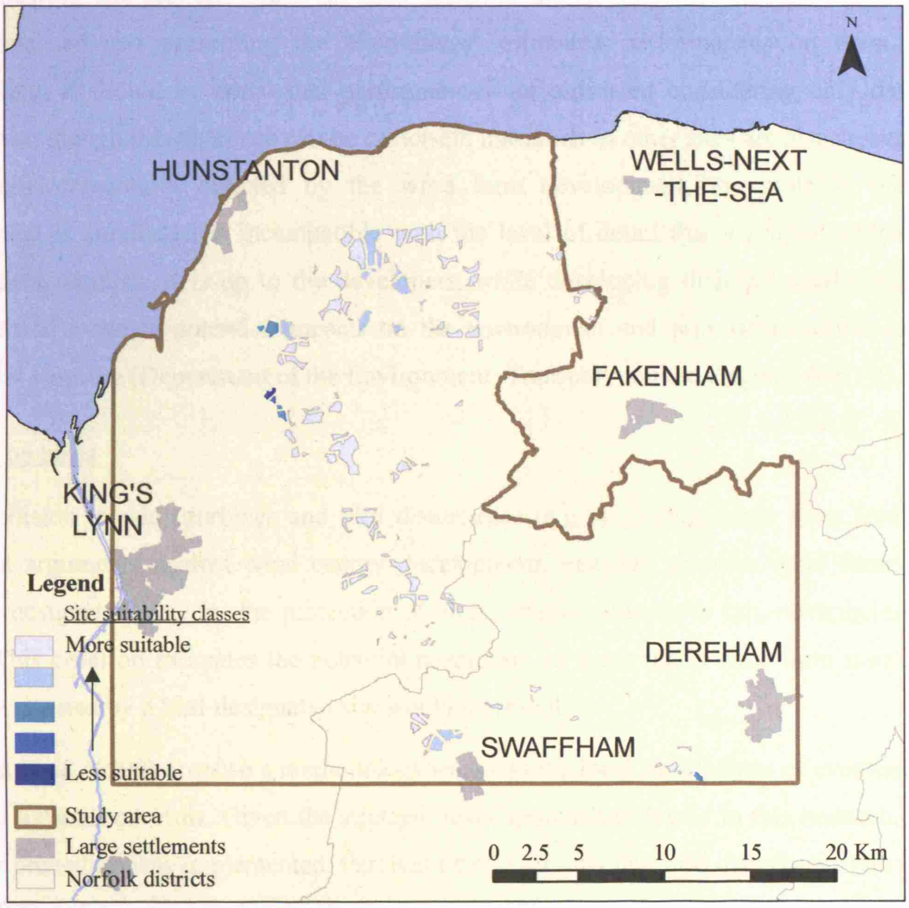


Figure V.22 – Standardised performances of feasible sites on the criterion impact on property value.

Ecology impact-related criteria

Nature conservation bodies oppose wind farm projects if impacts on ecology are perceived to compromise nature conservation objectives (EN *et al.*, 2001). During the process of identifying feasible sites for wind farms, national and international designated sites for their ecological value were excluded, based on the argument that obtaining planning permission for these locations would involve extra difficulties (*cf.* Table V.2). However, since birds and other species do not respect sites' boundaries (e.g. animal displacements), there might be a presumption against siting wind turbines nearby those sites. Criteria under the ecology umbrella account for this possible presumption. Three criteria were considered:

- impact on birds;

- impact habitats and species of international and national interest; and
- impact on habitats and species of local interest.

The following sub-sections focus on each criterion individually, describing how they were operationalised and presenting the alternatives' estimated performances on them. Before proceeding, it should be noted that performances are estimated considering only designated sites. Even though this approach can be criticised, inasmuch as other sites are also susceptible of being environmentally affected by the wind farm development, the scale at which the assessment is conducted is incompatible with the level of detail that a proper environmental assessment requires. It is up to the developers, while developing their proposal, to carefully analyse and evaluate potential impacts on the environment and propose measures to avoid/ minimise harming (Department of the Environment, Transport and the Regions (DETR), 1999).

Impact on birds

Bird collision to wind turbines and bird disturbance (e.g. displacing birds from feeding) are frequent arguments against wind energy development. Feasible sites for wind farms do not include designated sites for the protection of birds. Proximity to these can, nevertheless, be an issue. This criterion estimates the potential hazardous for birds that a wind farm installed in a feasible site nearby a bird-designated site would represent.

Percival *et al.* (1999) propose a methodology to assess the local significance of eventual impact of wind turbines on birds. Given the strategic level approach followed in this research, a much simpler procedure was implemented. Percival (2001) informs that bird disturbance can occur as far as 800 m from wind turbines. On the caution side, it was considered that hazard to birds extends up to 2 km from a wind turbine. A weighting scheme was created to translate the decay of potential hazard to birds with distance from wind turbines, Table V.14

Distance from wind turbines	Impact index (weight)	Normalised weight
Up to 800 m	10	0.77
800 m - 2 km	3	0.23
> 2 km	0	0.00
Total weight	13	1.00

Table V.14 – Weighting scheme to consider the decay of potential hazard to birds with distance from wind turbines.

The indicator adopted to operationalise this criterion was the extent of designated sites for the protection of birds, weighted by impact index from Table V.14. Table V.15 indicates the datasets involved in preparing the impact basis of calculus to assess performances on this criterion. A migratory bird paths dataset was also sought from EN but could not be obtained.

Apparently such a dataset does not exist; specialists need to refer to existing literature when analysing specific wind farm proposals, on a case-by-case basis.

Theme	Dataset	Dataset provider
SPA	Spatial Protection Area	English Nature via MAGIC
RSBP reserves	RSBP reserves	Royal Society for the Protection of Birds
IBA	Important Bird Areas	

Table V.15 – Datasets used in preparing the impact basis of calculus to assess performances on the criterion impact on birds.

Spatial analyses showed that only four wind farms are closer than 2 km from a designated area for the protection of birds (Pradhan, 2005: 32) Therefore, the performance of 113 feasible sites (out of 117) on this criterion is null. Figure V.23 shows this occurrence: feasible site with no impact on this criterion are shown in the lightest colour, darker colours are used to depict less suitable sites to accommodate a wind farm, from the point of view of this criterion.

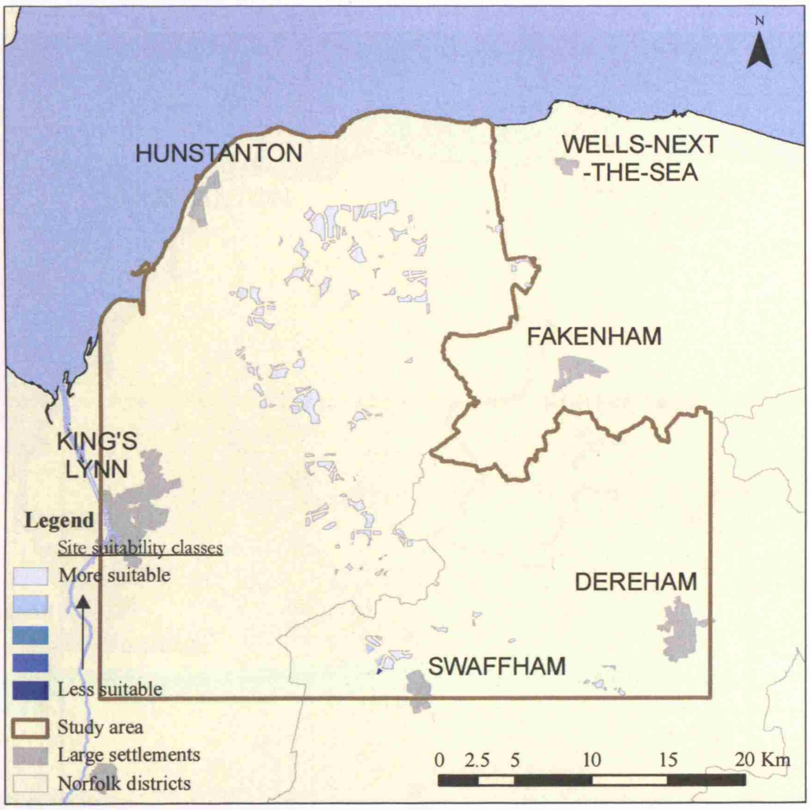


Figure V.23 – Standardised performances of feasible sites on the criterion impact on birds.

Impact on habitats and species of international and national interest

Impact on habitats and species was estimated in a similar manner to impacts on birds. Only two differences apply:

- instead of sites for the protection of birds, statutory and non-statutory designated sites for nature conservation purposes were considered (*cf.* Table V.16); and
- no potential disturbance decay function was considered within the impact zone.

Accordingly, the indicator adopted to operationalise the criterion was the extent of conservation areas within 2 km from a wind farm.

Theme	Dataset	Dataset provider
Ramsar Sites SAC National Nature Reserve SSSI unit	Natural heritage Areas	Countryside Agency via MAGIC
Wildlife sites	County wildlife sites	Norfolk County Council

Table V.16 – Datasets used for estimating performances on the criterion impact on habitats and other species than birds.

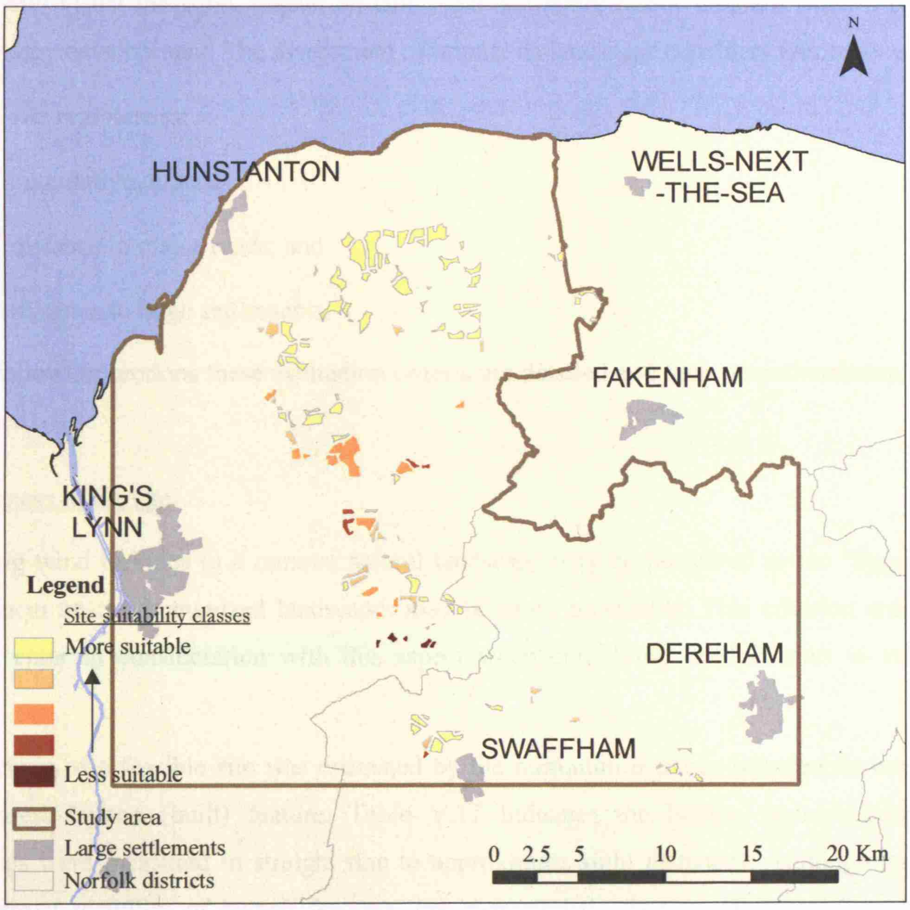


Figure V.24 – Standardised performances of feasible sites on the criterion impact on habitats and other species than birds.

Figure V.24 shows the standardised performances on the criterion. Darker sites depict less suitable sites for accommodating a wind farm, from this criterion point of view. Details of the calculation procedure are available from Pradhan (2005: 32), who implemented the script for performances assessment.

Impact on habitats and species of local interest

Impact on local habitats and species was estimated in a similar manner to the previous criterion. The adopted indicator to operationalise the criterion was the extent of local designated areas within 2 km from a wind turbine. The used impact basis of calculus was the Local Nature Reserves (LNR) dataset obtained from Breckland Council.

As no feasible site is located within 2 km proximity from a LNR, all alternatives have a null performance on this criterion. Hence, this criterion is irrelevant for decision-making.

Landscape impact-related criteria

Along with visual intrusion, impact on landscape is a major public concern when it comes to wind energy development. The assessment of impact on landscape considers four aspects:

- site remoteness;
- cumulative impact;
- distance to major roads; and
- distance to large settlements.

In the following sections these evaluation criteria are detailed and their operationalising method described.

Remoteness of the site

Installing wind turbines in a remote, natural landscape may be perceived as too “aggressive”; siting them nearby humanized landscapes may be more acceptable. This criterion enables the DM to enter in consideration with this aspect when classifying feasible sites in suitability classes.

Remoteness of a feasible site was estimated by the minimum distance between its border and the nearest human (built) feature. Table V.17 indicates the human features considered. Distances were measured in straight line to approximate sight distances. Although landforms can obstruct visibility of human features, the characteristic flatness of the area renders this approximation acceptable.

Theme	Feature type	Dataset	Dataset provider
Historic houses Airport Turistic attractions TV and radio masts Castles Abbey, Cathedrals and Priory	Point	OS Strategi®	EDINA Digimap
Operating wind turbines	Point	OS Strategi® updated by the author	EDINA Digimap
Railway Roads Canal	Line	OS Meridian™ 2	EDINA Digimap
Setlements	Polygon	Derived based on the population density surface, following the procedure proposed by Martin et al. (2000: 355)	

Table V.17 – Human features considered to assess the remoteness of a feasible site and respective datasets.

Figure V.25 depicts the procedure employed to estimate performances on this criterion. Three datasets (depicted in blue oval shapes) were created by compiling human features spatially represented by the same type (point, line and polygon). For each dataset, Euclidean distances were computed from the human features ("sources"); the result consists of raster datasets where each cell stores the minimum distance to a human feature.

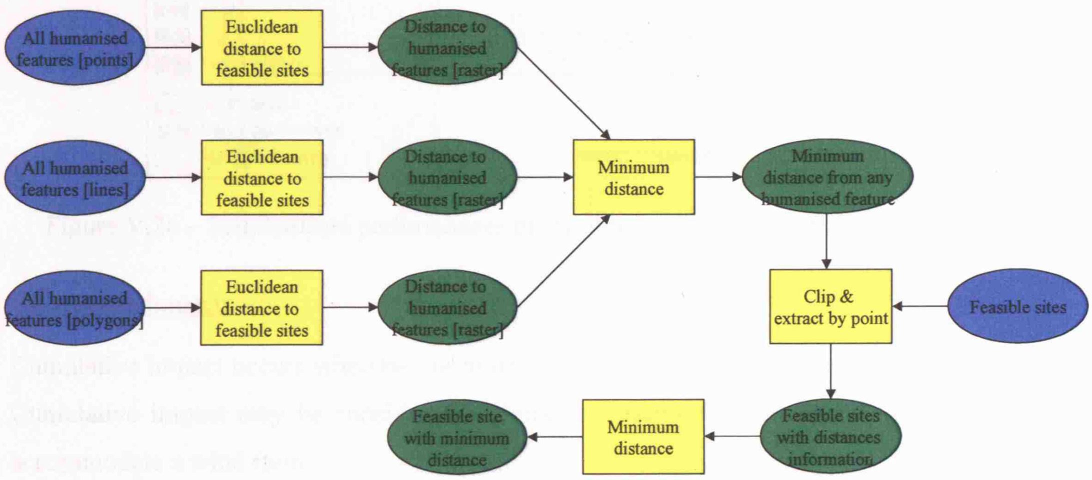


Figure V.25 – Procedure employed to estimate performances on the site remoteness criterion.

To find out the nearest human feature for each raster cell, all three datasets are involved in a raster operation that computes the minimum value for each cell. The resulting dataset corresponds to the impact basis of calculus. Finally, the impact basis of calculus was combined with the feasible sites dataset and, for each site, the minimum distance[35] stored in a raster cell falling within it was computed. This value corresponds to the site's performance on this criterion.

Figure V.26 shows standardised performances on this criterion. More remote sites (i.e. more distant from human features) are represented in darker colours. Assuming that remote sites are less suitable to accommodate wind farms, darker sites depict less suitable sites.

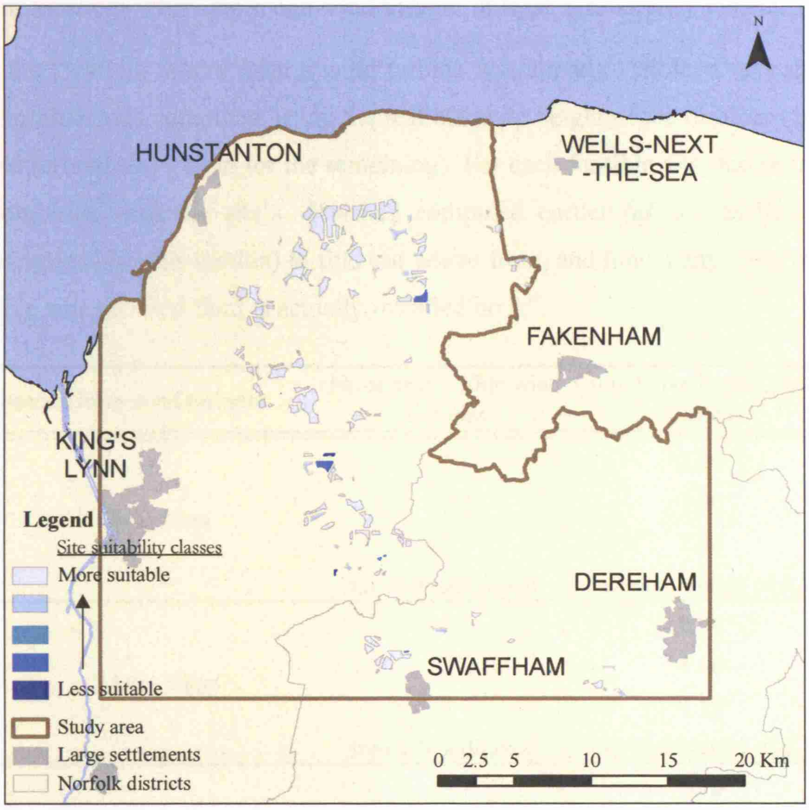


Figure V.26 – Standardised performances of feasible sites on the criterion site remoteness.

Cumulative impacts

Cumulative impact occurs when two or more wind turbines are visible from the same location. Cumulative impact may be considered an important factor for deciding on site suitability to accommodate a wind farm.

Cumulative impact should be assessed with reference to a base plan of all existing wind farms, consented developments and applications received (ODPM, 2004). As of August 2005, date when this study was conducted, two wind turbines operated in the study area (EcoTech and

[35] The minimum distance to a human feature was considered a better indicator than the means because it translates the worse-case scenario, i.e. when a wind turbine is placed right on the border of the feasible site.

Swaffham II) and a project of eight wind turbines had already received planning permission (North Pickenham wind farm). Therefore, ten turbines constituted the basis scenario for cumulative impact assessment.

To operationalise the criterion, the selected indicator was the aggregated extent where from cumulative impact can be perceived, weighted by the number of new visible wind turbines, and the distance to the closest visible turbine. This indicator implies that cumulative impacts can only be felt in locations where from one wind turbine, at least, was already visible.

To find out the locations where from a wind turbine was already visible, a viewshed from the ten existing turbines was computed, using the real blade tip height of the turbines (100 m for the Ecotech wind turbine and 120 m for the remaining). For each feasible site, the resulting dataset was then combined with the site's viewshed computed earlier (*cf.* sub-section Step three: viewsheds computation, this section) to find out where from, and how many, new wind turbines become visible when a wind farm is actually installed on it[36].

Distance from wind turbines	Nr of new visible wind turbines	Cumulative impact index (weight)
Up to 2 km	1	1.00
	2	1.20
	3	1.40
	for each additional	increase weight of 0.2
2 km - 5 km	1	0.90
	2	1.00
	3	1.10
	for each additional	increase weight of 0.1
5 km - 15 km	1	0.70
	2	0.75
	3	0.80
	for each additional	increase weight of 0.05
15 km - 20 km	1	0.50
	2	0.52
	3	0.54
	for each additional	increase weight of 0.02

Table V.18 – Weighting scheme used for computing cumulative impacts.

To account for the number of new visible wind turbines on estimates of cumulative impact, the weighting scheme shown in Table V.18 was devised. Since no scientific study informs about

[36] The combination consisted in a conditional statement that for each location (cell) where from an existing wind turbine was already visible, the number of new visible wind turbines is stored; otherwise, no-data is stored, corresponding to no cumulative impact occurring at this location.

how perceived cumulative impact varies with the number of visible wind turbines, in devising this scheme it was assumed that the greatest impact is felt when one new wind turbine becomes visible. If two new wind turbines become visible, the cumulative impact does not double, but increases of a smaller percentage in relation to that caused by visibility of the first new wind turbine. The increase depends on the distance to the visible wind turbine as specified in Table V.18.

Pradhan wrote the scripts to automate performances computation on this criterion - details of the process can be found in Pradhan (2005: 36). Figure V.27 shows standardised performances on the criterion. Darker sites depict less suitable sites, i.e. sites impinging greater cumulative impact.

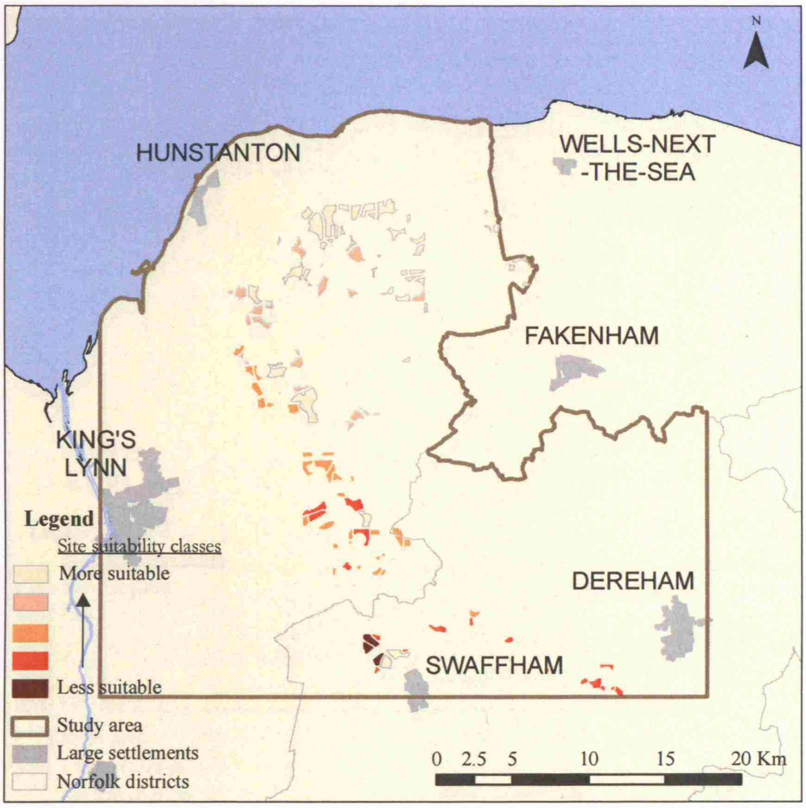


Figure V.27 – Standardised performances of feasible sites on the criterion cumulative impact.

Proximity to main roads

Earlier, the criterion visual impacts on road users considered feasible sites closer to main roads less suitable for wind farms (*cf.* sub-section Visual impact on road users, this section). From the landscape point of view, the opposite might be preferable. It can be argued that travellers in major roads are not as interested on the landscape as travellers in minor roads[37], where lower speed enables greater opportunity to appreciate the landscape. This criterion enables to consider this aspect for decision-making on site suitability to accommodate a wind farm.

Operationalisation of this criterion was based on estimates of the minimum distance between the borders of a feasible site and major roads. A- and B-road types, as classified in the OS Meridian™ 2 dataset, were considered (no highway exists in the study area). Euclidian distances were computed as an approximation to sight distances.

Figure V.28 shows standardised performances on this criterion. Feasible sites further away from main roads are considered less suitable for accommodating a wind farm, and are depicted in darker colours.

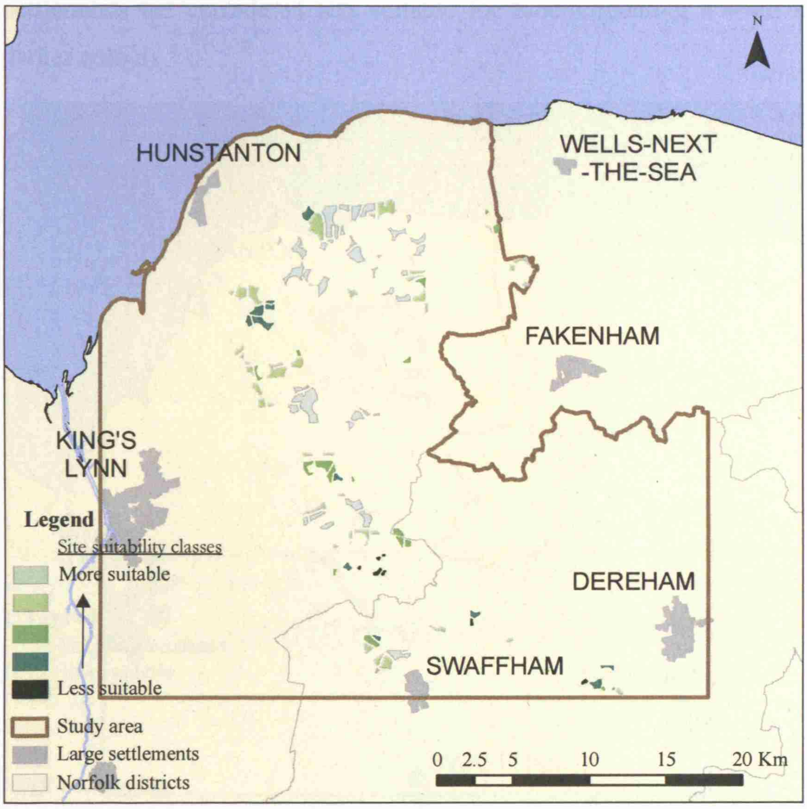


Figure V.28 – Standardised performances of feasible sites on the criterion proximity to main roads.

Distance to large settlements

Similar to the previous case, from the landscape point of view, it can be argued that wind turbines should be sited closer to larger settlements, so the conspicuousness of their structures

[37] This assumption is considered true both for drivers and passengers as there is no objective way to distinguish them for the purpose of this analysis.

can be "absorbed" by the surrounding landscape (industrial and big commercial estates that often exist at the entrance of large settlements). A further argument is that wind turbines located closer to electricity consumer centres reduce electricity losses over the grid network. This criterion allows the consideration of these aspects for decision-making.

To operationalise the criterion, distances from the feasible sites to the closest large settlement were estimated. Settlements over 2,000 inhabitants were considered large. Settlements were demarcated following the procedure suggested in Martin *et al.* (2000: 355). Euclidean distances were computed between outer borders, in a procedure matching that applied in the previous criterion.

Figure V.29 shows the standardised performances on this criterion. Feasible sites further away from large settlements are considered less suitable for accommodating a wind farm and are depicted in darker colours.

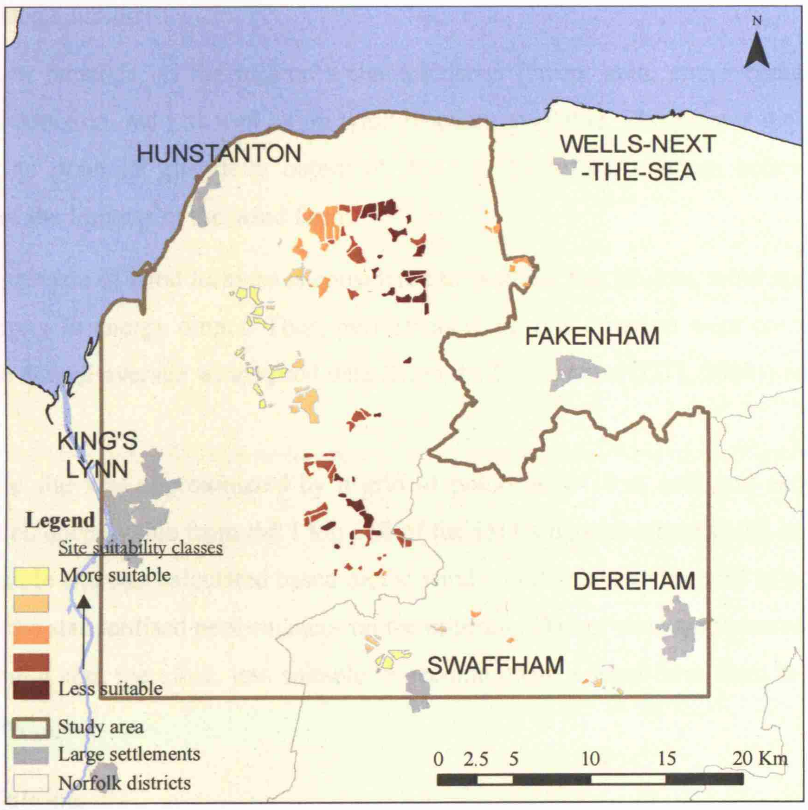


Figure V.29 – Standardised performances of feasible sites on the criterion distance to large settlements.

Noteworthy, between a feasible site and the closest large settlement, smaller settlements often exist. The size of the closest settlement is an aspect considered in a different evaluation criterion (*cf.* sub-section Size of the closest settlement ahead).

Site-related criteria

In addition to impingements by a wind farm located at a feasible site, the site characteristics may also play a role when deciding on its suitability to accommodate a wind farm. Four site characteristics were considered relevant:

- estimated energy output;
- size of feasible site;
- agricultural value of the feasible site; and
- size of the closest settlement.

These were taken as evaluation criteria. The following sub-sections explain how these criteria were operationalised for performances assessment.

Estimated energy output

Energy output depends on the turbine's characteristics (swept area, curve characteristic for electricity production, etc.) as well as on wind resource available. The greater the wind speed, the greater the potential electricity output of the site. Therefore, one can believe, the more justifiable are the impacts of the wind farm.

Since a unique type of wind turbines is considered throughout this project, wind speed data was used as a proxy to energy output. Thus, performances on this criterion were computed as the means of the annual average wind speed data (from the DTI dataset (DTI, 2004)) registered at a site.

Each feasible site was approximated by a grid of points with 10 m cell, and each point was given the wind speed value from the 1 km cell of the DTI's dataset where it fell in. The means for each feasible site was calculated based on the wind speed values of the grid of points. Figure V.30 shows the standardised performances on the criterion. Darker sites are those with less wind energy potential and, therefore, less suitable to accommodate a wind farm from this criterion's point of view.

Size of feasible site

There is an ongoing debate about the size of wind turbines clusters: is it preferable to have more clusters of small wind turbines or have fewer, bigger wind farms? This criterion brings this issue into consideration for site suitability decision-making.

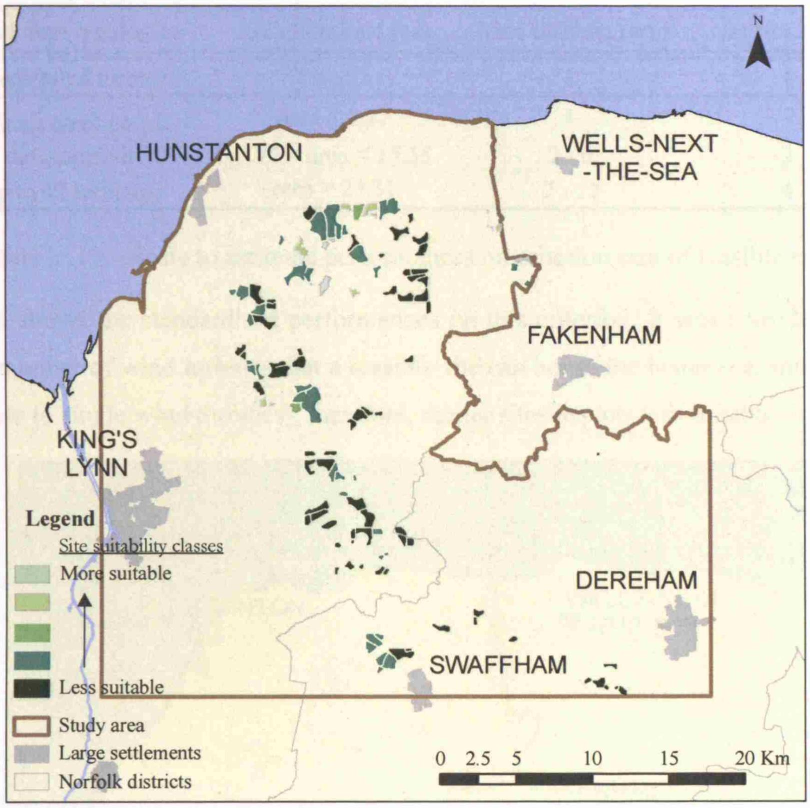


Figure V.30 – Standardised performances of feasible sites on the criterion estimated energy output.

The indicator selected to operationalise this criterion was the number of turbines that a feasible site can house. To find out this figure, design guidelines for a wind farm layout were considered (*cf.* sub-section Step one: positioning fictitious wind turbine; DWEA, 2006). Again assuming the minimum recommended separation between wind turbines (i.e. 5 rotor diameters apart in the prevailing wind direction and 3 rotor diameters in the perpendicular direction), the minimum area required to install one turbine integrating a cluster is 7.77 ha ((3 x 72) x (5 x 72) m^2).

In reality, if wind turbines are positioned in the corners of a regular grid, 7.77 ha is enough area to accommodate 4 wind turbines (*cf.* Figure V.9). Based on this principle, the minimum area to accommodate 6 turbines is 15.55 ha (2 x 7.77 ha) and to accommodate 12 turbines is 38.85 ha (5 x 7.77 ha). Using these thresholds an impact scale was developed to assess performances of feasible sites on this criterion, Table V.19. The scale considers only the two wind farm typologies possible within the study area: single turbines and small size developments (*cf.* sub-section Step one: positioning fictitious wind turbine).

Wind farm typologies	Area threshold (ha)	Wind turbines (no.)	Impact index
Single wind turbine	any	1	1
Small wind farm	area ≤ 7.77	1	1
development	7.77 < area ≤ 15.55	2 - 6	3
(up to 12 turbines)	area > 23.31	7 - 12	4

Table V.19 – Scale to estimate performances on criterion size of feasible site.

Figure V.31 shows the standardised performances on this criterion. It was considered that the greater the number of wind turbines that a feasible site can house the better (i.e. smaller clusters are preferable to single wind turbines), therefore, darker sites depicts less suitable sites.

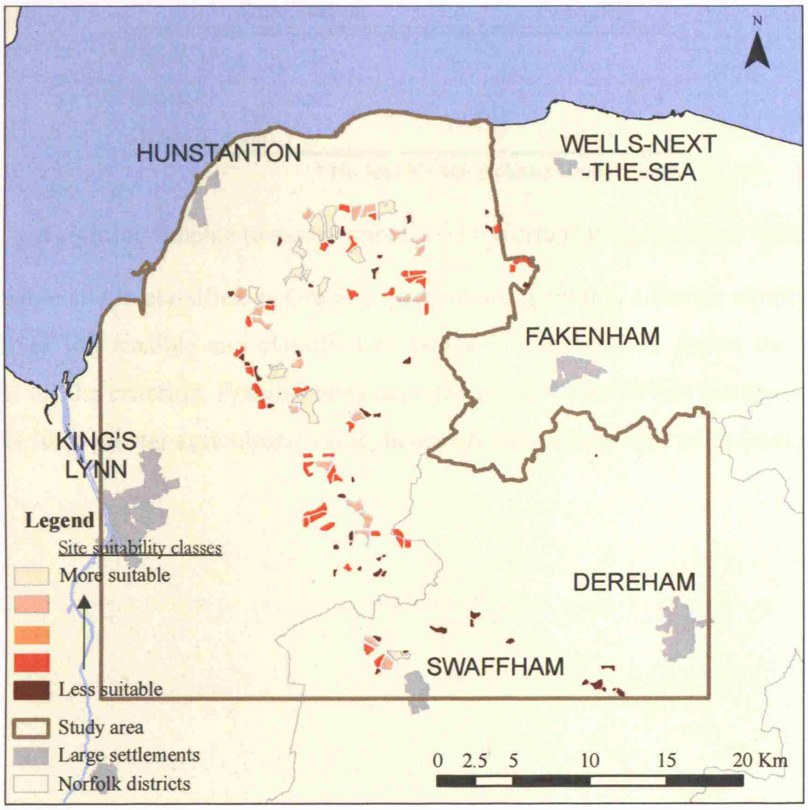


Figure V.31 – Standardised performances of feasible sites on the criterion size of feasible site.

Agricultural value of the site

Land is an important and scarce resource; hence, it should be judiciously allocated. Wind farms are a competing land use. Certain types of land, such as brownfields or industrial estates, might be thought more adequate to site a wind farm than others. This criterion takes into consideration the site's suitability for agricultural purposes. It is a relevant criterion because wind farms are often located in agricultural sites. Moreover, it represents a feasible instance of a more comprehensive criterion conceived: the suitability of a feasible site based on the current land use (or land cover). Indeed, the operationalisation of this latter criterion was impossible because no land cover classification was available[38] and attempts to devise one from satellite images resulted unsatisfactory.

DEFRA classifies agricultural land in five quality classes, being Grade 1 the most valuable for agricultural purposes and Grade 5 the least valuable. Baban and Parry (2001) indicate that agriculture land of grades 1 and 2 are less suitable for wind farm siting. Thus, this criterion was operationalised as the aggregated extent of the feasible site weighted by the agricultural value of the land that it occupies. Table V.20 shows the adopted agricultural land value weighting scheme.

DEFRA's agricultural land classification	Impact index (weight)
Grade 1*	2
Grade 2	1
Grade 3, 4 and 5	0

* No feasible site includes Grade 1 land.

Table V.20 – Weighting scheme to assess impacts on the criterion agricultural value of the site.

Since no feasible site is classified as Grade 1, performances on this criterion simply correspond to the extent of the feasible site classified as Grade 2. Figure V.32 shows the standardised performances on the criterion. Feasible sites depicted in light blue do not occupy land of grade 2; darker sites have greater agricultural value; hence are less suitable for wind farm siting.

[38] The UCL Department of Geography did not hold a license for the Land Cover Map of Great Britain 2000 Classification (http://www.ceh.ac.uk/sections/seo/lcm2000_continued.html), for instance.

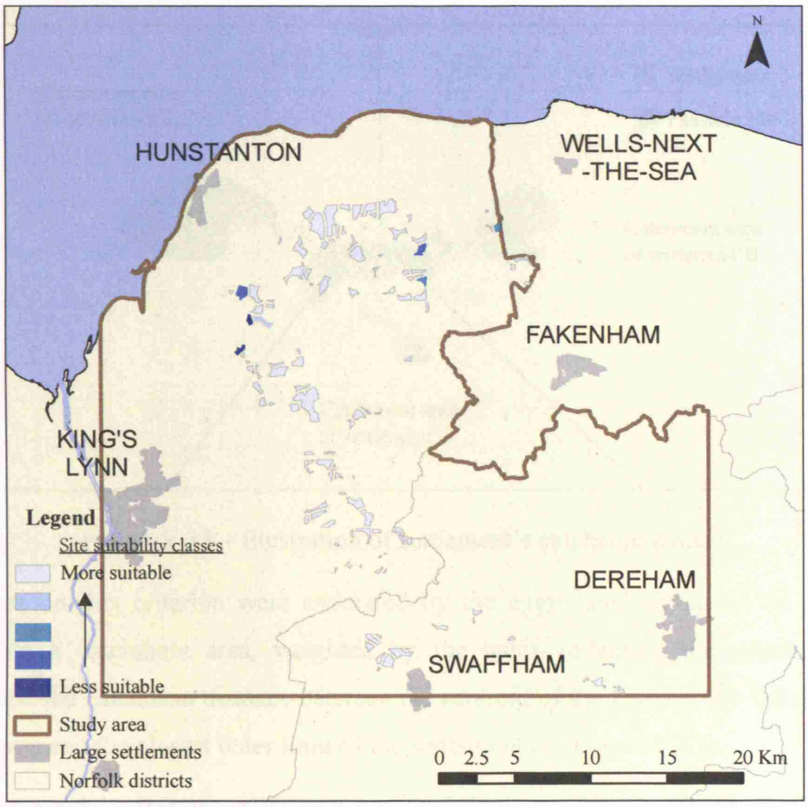


Figure V.32 – Standardised performances of feasible sites on the criterion agricultural value of the feasible site.

Size of the closest settlement

Is it preferable to localise wind farms close to large or small settlements? Smaller settlements may benefit from the "marketing" potential arising from having a significant percentage of electricity demand satisfied from green (wind) energy. Larger settlements have greater potential to absorb the turbines landscape impacts. The size of the closest settlement can be relevant for deciding on the suitability of a feasible site to accommodate a wind farm.

Due to the shape of feasible sites, the closest settlement may vary according to a considered location. To identify the closest settlement to the feasible site (or part of), catchment areas of settlements were calculated. These correspond to "areas of influence" of a settlement and enable easy recognition of which parts of a feasible site are closer to which settlement, Figure V.33. Catchment areas were calculated using the Voronoi diagram technique, an in-built function in most contemporaneous GIS ("allocation" function in ArcGIS 9.1).

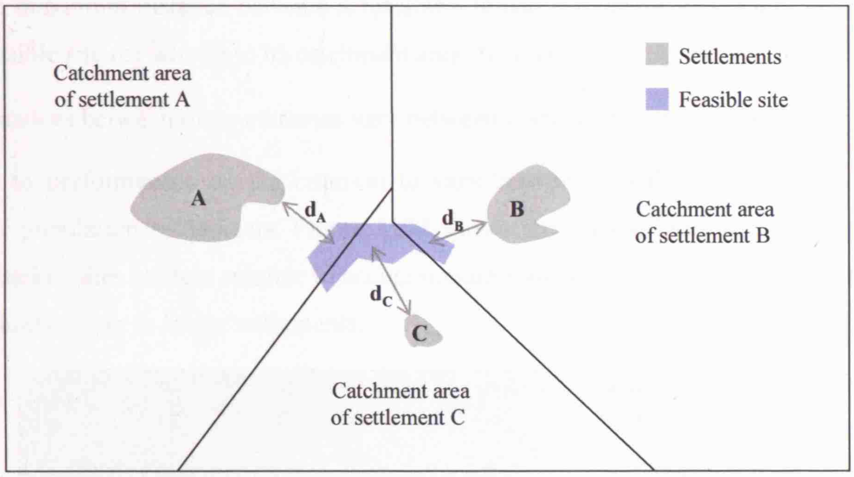


Figure V.33 – Illustration of settlement's catchement areas.

Performances on this criterion were estimated by the aggregated extent of the feasible site falling within a catchment area, weighted by the index reflecting the population of this settlement and the Euclidean distance between the centroid of the feasible site falling within the catchment area and the closest outer limit of the settlement (*cf.* Figure V.33).

Settlements were delimited according to the methodology proposed in Martin *et al.* (2000: 355) and the adopted population-based index scheme is shown in Table V.21.

Settlement population (inhabitants)	Impact index (weight)	Normalised weight
pop. < 500	1	0.17
500 < pop. ≤ 2,000	2	0.33
2,000 < pop. ≤ 10,000	3	0.50
pop. > 10,000*	4	--

* No settlements over 10,000 inhabitants exist in the study area.

Table V.21 – Weighing scheme used to estimate impacts on the criterion size of the close settlement.

From Table V.21, performances on the criterion are directly proportional to the size (population) of the settlements in which catchment areas the feasible site falls in. In addition, performances are inversely proportional to the distance between the sites's (or part of) centroid and the boundary of the closest settlement. That is, the further away the settlement is, the less "influence" it has over the feasible site. For simplicity, distances were standardised according to:

- the minimum distance between a feasible site and a settlement was considered 1;

- the maximum distance between a feasible site and settlement which includes part of a feasible site (or whole) in its catchment area (found to be 2 km) was considered 0; and
- distances between these extremes vary between 0 and 1, in a proportional reason.

This leads to performances on the criterion to vary between 1 and 3, based on the indexes defined for population settlements. Figure V.34 shows the standardised performances on the criterion. Darker sites are less suitable to accommodate a wind farm, assuming it is preferable to site wind farms closer to larger settlements.

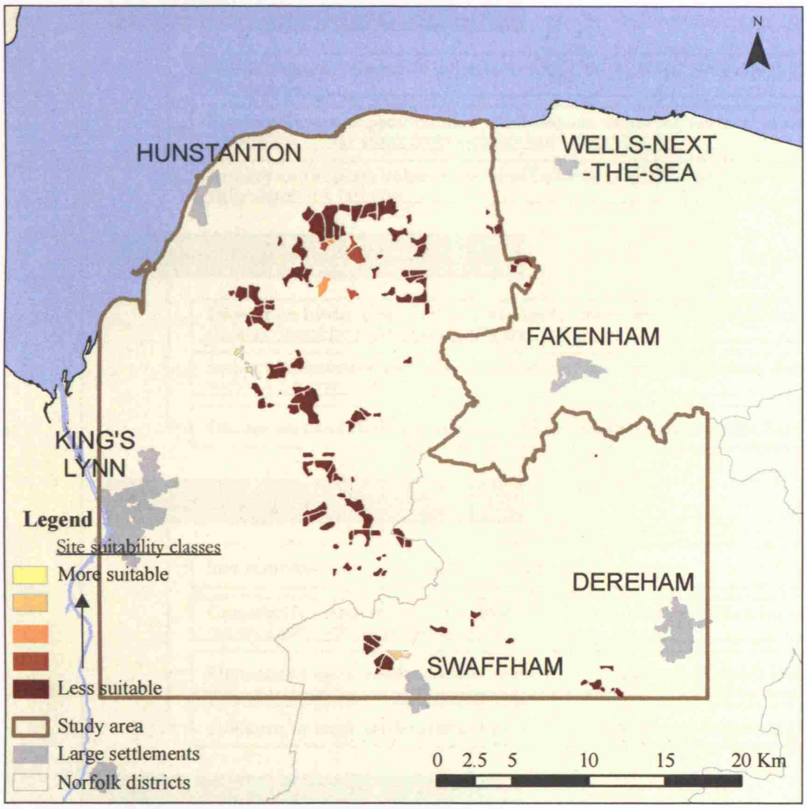


Figure V.34 – Standardised performances of feasible sites on the criterion size of the closest settlement.

Summary

Figure V.35 summarises the indicators used to estimate performances on the identified set of evaluation criteria. For each criterion, alternative indicators to operationalise it could have been chosen, which, very likely, would have implications on the alternatives' performances assessment. In support of the selected indicators, two arguments can be put forward:

- whenever possible, concepts, methods and methodologies applied in this research were pulled out from the literature; and
- double counting of impacts was avoided, which naturally would bias decision-making.

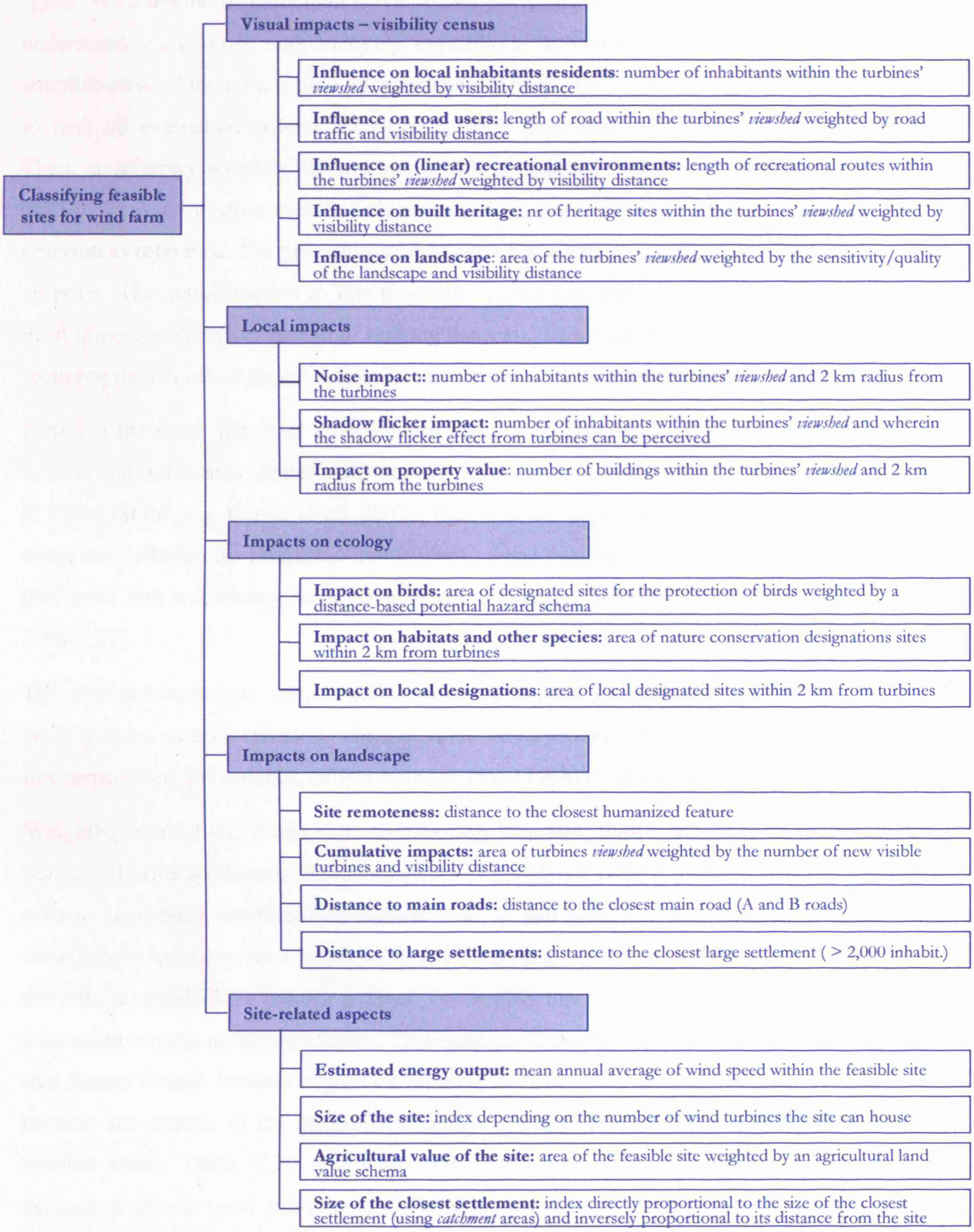


Figure V.35 – Indicators used to estimate performances on the defined evaluation criteria.

V.4.2. Modelling decision-maker's preferences

With the problem structured, the DM's preferences with regard to decision-making need to be elicited (*cf.* section II.3.2.3, sub-section Decision maker's preferences). Various techniques exist to elicit DM's preferences; the application should guide the selection (section II.3.2.3). To “grab” the attention of participants, web-based public participation systems require a simple to understand, easy-to-use and relatively expeditious technique. The selected technique was a simplification of the ratio estimation procedure (Easton, 1973). This procedure requires the DM to rank all evaluation criteria according to their perceived importance for decision-making. Then, an arbitrary weight/score (normally 100) is assigned to the most important criterion and the DM is asked to give smaller weights to criteria lower in order, having the most important criterion as reference. The procedure terminates when a weight is assigned to the least important criterion. The simplification to this procedure consists in asking the DM to identify only the most important criterion instead of ranking them all. This reduces the burden on the DM, while retaining the important aspect that is the identification of the most important criterion.

Defining the most important criteria helps the DM to rationalise relative importance between criteria and, ultimately, better understanding the weighting mechanism. Carver and colleagues, in their OSDM (e.g. Carver *et al.*, 2002a; Carver *et al.* 2002b), elicit DM’s preferences without using any criterion for reference. Interestingly, when evaluating the system’s usage, they noted that users had a tendency to misunderstand the criteria weighting mechanism (Evans *et al.*, 2004: 127).

The selected technique can, nonetheless, be criticised for ignoring the range (spread) of performances on each criterion, when, clearly, the importance of a criterion depends on it (with this respect, see, for instance, Edwards and Barron (1994) or Malczewski (1999a)).

Weighting evaluation criteria is a complex cognitive task, with complexity increasing with the number of criteria (Cohon, 1978; Jankowski *et al.*, 2001). During problem structuring nineteen criteria have been identified (*cf.* section V.4.1.2, sub-section The evaluation criteria). These were judged too many for a layperson to evaluate via a website. In addition to the complexity of the task, it would likely become tedious. To simplify this task, it was decided to pre-weight the evaluation criteria under each factor. Proceeding in this way, the DM will only have to weight five factors (which become evaluation criteria), instead of the nineteen original criteria (which become sub-criteria of the problem) to obtain a recommendation (i.e. a classification of the feasible sites). Table V.22 shows the default weights used in pre-weighting the original evaluation criteria (now sub-criteria). The technique used to weight these sub-criteria was the same used during the process of identifying a study area: the swing weight technique (*cf.* section IV.5.4.4). The DM will be given the possibility to change the default weights and create their own preferences model.

Criteria	Sub-criteria	Default weights		Measuring unit	Type	Editable
		raw	standardised			
Visual impact	on local inhabitants	100	0.31	no. of inhabitants	Cost	No
	on road users	25	0.08	km of roads	Cost	No
	on recreational environments	80	0.25	km of recreational paths	Cost	No
	on built heritage	40	0.12	no. qualified buildings/monuments	Cost	No
	on landscape	80	0.25	area of designated sites	Cost	No
	TOTAL	325	1.00	-- --	--	--
Local impacts	noise impact	100	0.56	no. of inhabitants	Cost	No
	shadow flicker effect	60	0.33	no. of inhabitants	Cost	No
	on property value	20	0.11	no. of buildings	Cost	No
	TOTAL	180	1.00	-- --	--	--
Impact on ecology	on birds	100	0.50	area of bird-designated sites	Cost	No
	on habitats and other species	100	0.50	area of nature conserv.-designated sites	Cost	No
	on local designations	0	0.00	area of local designated sites	Cost	No
	TOTAL	200	1.00	-- --	--	--
Impact on landscape	site remoteness	100	0.28	km	Cost	**Yes**
	cumulative impacts	100	0.28	area where new turbines are visible from	Cost	No
	distance to main roads	100	0.28	km	Cost	**Yes**
	distance to large settlements	60	0.17	km	Cost	**Yes**
	TOTAL	360	1.00	-- --	--	--
Site-related aspects	estimated energy output	100	0.26	m/s	Benefit	No
	site's size	0	0.00	non-dimensional	Cost	**Yes**
	agricultural value of the site	70	0.18	area with high agricultural value	Benefit	No
	size of the closest settlement	40	0.11	non-dimensional	Benefit	**Yes**
	TOTAL	380	1.00	-- --	--	--

Table V.22 – Weight and type of sub-criteria involved in decision-making on wind farm siting.

During sub-criteria (former criteria) operationalisation, decisions had to be made regarding the type of the criterion, whether cost or benefit[39]. For some sub-criteria the choice was obvious (e.g. the greater number of inhabitants affected by the shadow flicker effect of a wind turbine, the worse); for others any decision might be disputable. Is it better or worse to locate wind turbines in remote sites? For the sub-criteria which type was considered controversial, it was decided to give the users the possibility to change the default type. The column of Table V.22 entitled 'Type' shows the selected type for each criterion; the column entitled 'Editable' identifies the sub-criteria for which it is possible to change the default type (highlighted in bold).

V.4.3. Selecting a decision-making technique

Once the performances of the feasible sites are assessed and the importance of the evaluation criteria defined, the next step in the process is defining the decision rule for decision-making (*cf.* section II.3.2.3). The decision problematic determines the range of decision rules adequate to the problem (*cf.* sub-sections Problem definition and Decision rules, section II.3.2.3).

[39] Cost criteria are those which larger estimated values actually correspond to poorer performances (e.g. development cost). Conversely, benefit criteria are characterised by the larger the estimated value, the better the performance (e.g. electricity production in hydroelectric plants) (*cf.* section IV.5.4.3).

As it was formulated (*cf.* section V.4.1), the decision problem at hand fits in the sorting problematic; a problematic concerned with the assignment of a set of alternatives into predefined homogenous groups (i.e. categories or classes) (Roy, 1985; 1996). The sorting problematic comprises two major types of assignment problems: classification problems and sorting problems. They differ with respect to the way the classes are defined. In classification problems, classes are defined in a nominal way; in sorting problems, classes are defined in an ordinal way, from those including the most preferred alternatives to those including the least preferred alternatives. The three pre-defined classes for the current planning problem (i.e. `recommended`, `acceptable` and `unacceptable` sites for wind farm) have an implicit ordinal logic; therefore the decision problem can be said of type sorting.

Zopounidis and Doumpos (2002) identity two widely used decision rules to tackle sorting problems: the outranking relation and the utility function. In the context of sorting problems, the outranking relation allows to conclude that an alternative a_i outranks a reference profile r_k that distinguishes the classes C_k and C_{k+1} if there are enough arguments to confirm that a_i is at least as good as r_k, while there is no essential reason to refute this statement. Once the outranking relation is constructed, its exploitation to sort the alternatives is performed through heuristic assignment procedures. ELECTRE TRI is the most widely used MCDM sorting method that implements this approach (Roy and Bouyssou, 1993). Variants to this method have been proposed, both in relation to the outranking relation and the assignment procedure (Belacel, 2000; Perny, 1998). Applications exist in a wide range of sectors, including medical (Belacel, 2000; Belacel *et al.*, 2005) and energy (Georgopoulou *et al.*, 2003; Mavrotas *et al.*, 2003).

The utility function provides an overall measure of the performance of an alternative a_i when all evaluation criteria are considered. This global utility serves to sort alternatives into classes, through comparison to utility thresholds defining the lower bound of each class, as follow:

$$\begin{aligned} &U(a_i) \geq u_1 \Rightarrow a_i \in C_1 \\ &u_2 \leq U(a_i) < u_1 \Rightarrow a_i \in C_2 \\ &\dots\dots\dots\dots\dots\dots \\ &U(a_i) < u_{q-1} \Rightarrow a_i \in C_q \end{aligned} \qquad (6)$$

where,

$U(a_i)$: global utility of an alternative a_i;

u_k : lower utility threshold for class C_k; and

q: number of classes.

The utility function can be any that correctly models the DM's preferences transforming the scale of an evaluation criterion into utility/value terms. The multiplicative utility function provides a general preference modelling form (Keeney and Raiffa, 1976), but a widely used for its simplicity and ease of use is the additive utility function (Siskos *et al.*, 2005; see also section II.3.2.3, sub-section Decision rules). This approach is used in the UTADIS method (Zopounidis and Doumpos, 1999) but alternatives have also been proposed, for example, in the M.H.DIS method by Zopounidis and Doumpos (2000).

In spite of the attractiveness of the outranking relation-based methods, namely due to their partial compensatory character, admission of incomparability relation, and explicitly consideration of uncertainty inherent to the decision-making process, two reasons make them unsuitable for public participation purposes. First, the outranking relationship is typically very difficult for a layperson to grasp. Second, it requires the elicitation of a great number of parameters from the DM (the ELECTRE TRI method requires criteria weights, for each category, a preference, indifference and veto threshold, and a cut-off threshold parameter, λ).

A number of authors have been working on ways to overcome this last problem by devising mechanisms to infer some parameters from exemplary decisions made on reference alternatives (see, for example, work by Dias and Mousseau, 2003; Dias *et al.*, 2002; Mousseau *et al.*, 2001; Mousseau *et al.*, 2000; Mousseau and Slowinski, 1998; and Ngo The and Mousseau, 2002). However, new difficulties are created, the major of which is the complexity of these inference procedures (Dias and Mousseau (2003) illustrate this complexity using IRIS, an ELECTRE TRI-based software with capabilities to infer certain parameters). This complexity demands a decision analyst to guide the DM through the "calibration" procedure, and this is incompatible with a web-based public participation system.

The additive utility function is a viable alternative. However, as explained in chapter II (section II.3.2.3, sub-section Decision rules), this method requires marginal utility function to be defined for all evaluation criterion. This is not an easy procedure and demands mediation by a decision analyst. Again, this is incompatible with the intended web-based system. Hence, a "compromised" solution was devised: due to the similarities between the additive utility function and the SAW (*cf.* section II.3.2.3, sub-section Decision rules), the latter was used in replacement of the former in the application of the sorting procedure outlined in (6). This technique has already been applied in the context of public participation (Carver *et al.*, 1996; Carver *et al.*, 2002a; Carver *et al.*, 2002b).

The SAW technique was introduced in chapter IV (section IV.5.4.5). To apply the sorting procedure implied in expression (6), the lower category limits shown in Table V.23 were set.

Classes of suitability to accommodate a wind farm	Lower overall impact threshold
Recommended	70
Acceptable	45
Non-acceptable	0

Table V.23 – Thresholds for the three pre-defined classes of site suitability for wind a farm.

Accordingly, a feasible site with an overall impact of 62 obtained from the SAW technique will be classified as an acceptable site to accommodate a wind farm, whereas a feasible site with an overall impact of 76 will be classified as a recommended site.

V.4.4. Logical model

In WePWEP's second tier, each participant, playing the role of the DM, will be involved in weighting evaluation criteria to classify the feasible sites into suitability classes for wind farm development (*cf.* section V.4.1). The participants, the feasible sites, the evaluation criteria, etc., are *entities* implicated in the logical functioning of the tier. *Relationships* can be recognised between some of these entities. For example, a participant *weights* an evaluation criterion and a feasible site *has a performance* estimated/assessed on a criterion. The identification of all entities and their relationships is essential for the correct implementation of WePWEP. Figure V.36 specifies the entities involved in WePWEP's second tier and their relationships. Entities are depicted using rectangles and relationships through links.

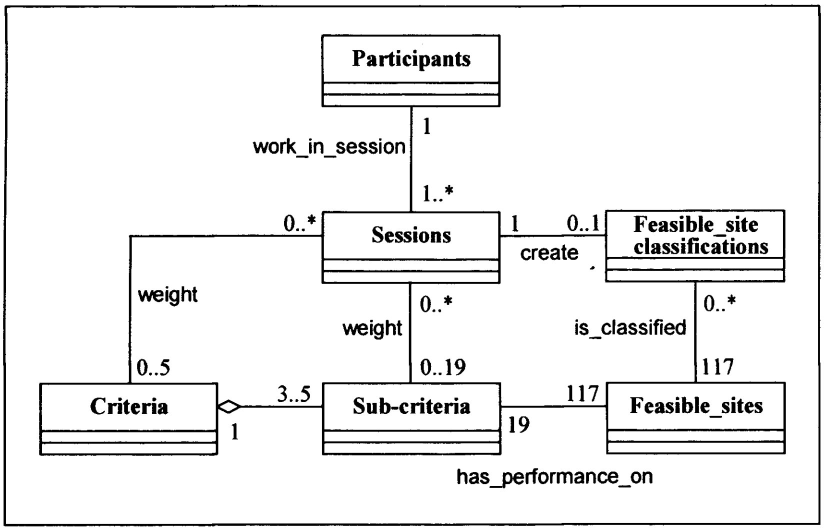


Figure V.36 – Logical model underlying WePWEP's second tier.

Six entities can be recognised:

- Participant or WePWEP user;

- Session;
- Feasible site;
- Criterion;
- Sub-criterion; and
- Classification of feasible sites.

Each relationship has two cardinalities associated, one to each direction from which the relationship can be read. The cardinality tells about the number of instances of the entity involved in the relationship. For example, the cardinality '0..5' nearby the entity 'Criterion' in the relationship 'weight' means that, in one session, a participant *can weight* from none up to five criteria. In the same relationship, the cardinality '0..*' nearby the entity 'Session' means that one criterion *can be weighted* in any number of sections, including none.

Figure V.36 can be read as follow. WePWEP is used in sessions. A new session will be initiated each time a participant uses the system and terminated when s/he leaves the system; this is represented by the *work_in_session* relationship. The cardinalities of this relationship say that one participant can work in many sessions, but each session has to be associated to exactly one participant. During a session, the participant can weight up to five criteria (*weight* relationship), up to nineteen sub-criteria (*weight* relationship) and create one (or none) classification of feasible sites (*create* relationship). The relationship *is_classified* indicates that a feasible site can have various classifications, including none, and a classification implies the classification of 117 feasible sites.

The entities in the bottom row of Figure V.36 relate to known parameters of the problem. The relationship between 'Criterion' and 'Sub-criterion' entities indicates that one criterion *aggregates* between three to five sub-criteria (*cf.* Figure V.6); and the relation between 'Sub-criteria' and 'Feasible_sites' indicates that each feasible site *has a performance* on each of the nineteen sub-criteria, and each sub-criterion has 117 performances of feasible sites associated.

V.4.5. Structural design and content overview

The structural design adopted for WePWEP's second tier is similar to that of Carver and his colleagues' OSDM systems (Carver *et al.*, 2002b; Kingston *et al.*, 1999).

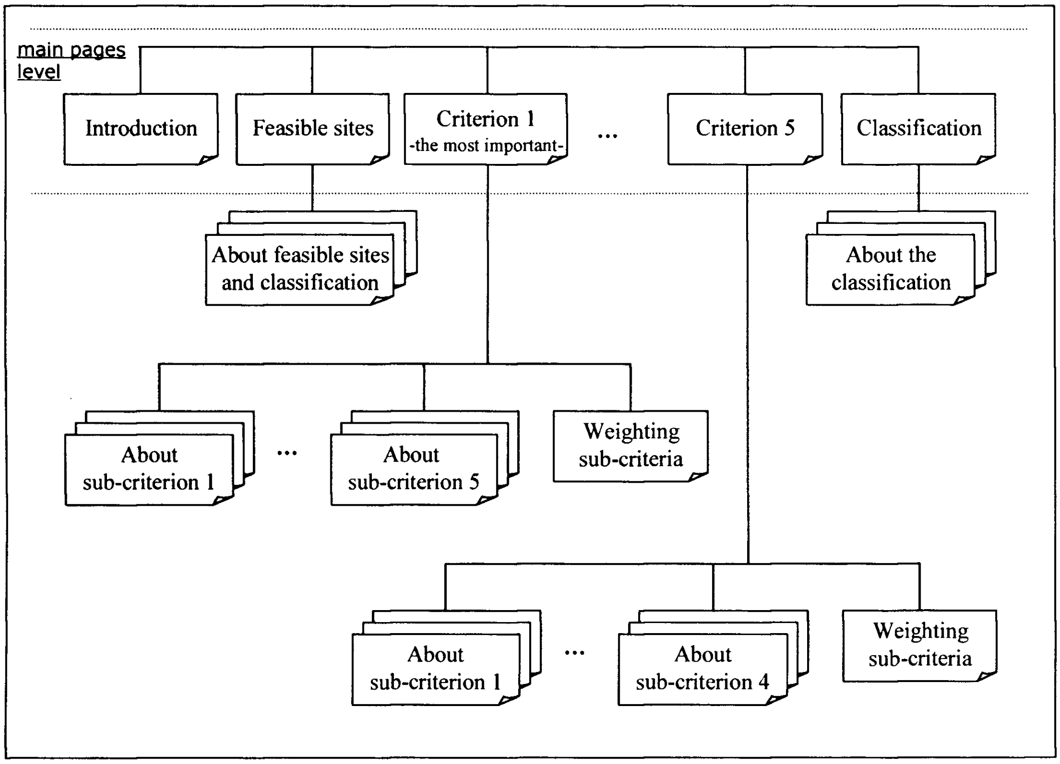


Figure V.37 – Structural design of WePWEP's second tier.

As Figure V.37 shows, the tier comprises eight main webpages and many secondary webpages, accessible from the corresponding main webpage. The first main page introduces the tier and the task the participant is asked to perform in it. The second main page introduces the feasible sites and the five evaluation criteria; it also asks the participant to identify the criterion that s/he considers the most important for decision-making. From this page, access can be gained to each criterion webpage as well as to webpages reporting on how feasible sites were identified and how the classification of feasible sites will be generated.

The next main page is that of the selected most important criterion. This page provides information on the criterion and shows, on a map, the overall performances of feasible sites on it. It also allows access to the webpages containing information on the associated sub-criteria and the webpage where default weights of sub-criteria, used to compute the overall performances on the criterion, can be modified. Furthermore, this page explains that the following evaluation criteria should be weighted having this one as reference.

The next four main pages look similar. For the respective criterion, they provide similar information and functionality to the most important criterion webpage. In addition, they contain an input form to collect the weight the participant thinks the criterion should have for decision-making. The decision to create a webpage for each evaluation criterion bears on providing a simpler and structured user interface (*cf.* section III.3.2.2) that enables the participant to explore each criterion individually, at their own pace.

The last main page displays the classification of feasible sites generated based on the participant's input. It also implements the concept of sensitivity analysis. That is, it provides a mechanism for easy revision of stated criteria weights and generation of a new classification (*cf.* section II.3.2.3, sub-section Sensitivity analysis).

V.5. Third tier: map-based communication tool

WePWEP's third tier corresponds to an AM. A requirement for this tier is to be based on a simple argumentation model, to enable everyone to contribute to the ongoing discussion without fear of "damaging" the argumentation structure. As reviewed in chapter II (*cf.* section II.4.3), various implementations of the map-based communication tools exist that satisfy this requirement. For instance, Keβler's argumap, Tang's GeoDF and the spatial discourse prototype described by Roeder in the IntelCities project report.

V.5.1. Development options

When addressing the conceptual implementation of WePWEP' third tier, two options were explored:

- develop an AM from scratch, integrating cohesively an existing discussion forum with the mapping technology needed for the development of WePWEP's second tier; and
- select an existing AM implementation and adapt it to satisfy the requirements set for WePWEP's third tier.

The first option was found preferable as the final system would result more cohesive. The AS Dito was selected to realise the discussion forum. Its advantages over equivalent software packages are: (1) it does not require an extra software for reading submitted contributions (as newsgroups do); (2) it enables structuring the discussion (whereas bulletin boards typically list contributions in chronologic order, known as "flat view"); and (3) it allows participants to attach files (e.g. pictures, articles, essays, etc.) to their contribution (Bording, 2003). Nevertheless, difficulties in installing this software and lack of support by the software's authors determined a change in the strategy to follow.

Keβler's prototype was available at the time of development (Summer 2005) and met most of the third tier's requirements:

- integrates a map and a discussion forum in a single user interface;

- uses the ubiquitous tree structure in the discussion forum, which in conjunction to simple types of contribution (e.g. question and argument in favour), makes possible some type of discussion structuring without imposing undue loads on users;
- enables the user to interact with the map (zooming, panning, selecting layers) to explore, for example, particular areas in greater detail;
- offers interactive tools for the user to select specific geographical objects from the map, create new graphical objects and associate them to written contributions;
- allows flexible workflow: users can explore discussion contributions starting either from the map or from the discussion forum; and
- very importantly, it is web-based, open source, adaptable to different case studies and does not require the purchase of any piece of software.

In the end, the second option was followed and Keβler's prototype was selected to realise WePWEP's third tier.

V.5.2. "Social planning solution"

In addition to examining, exploring and participating in a planning debate, WePWEP's third tier should allow for two other use cases: inspect and explore the "social planning solution" (*cf.* section III.2.3). Attending to the formulation of the planning problem at hand, the "social planning solution" can result from the combination of all classifications of feasible sites developed by individual participants.

The selected combination form was to assign to each feasible site the class that it has been the most times classified into, that is:

$$\text{“social” classification}_i = Class\left(max\,\{Recom_i, Accept_i, Unaccept_i\}\right) \qquad (7)$$

where,

i: feasible site index;

$Recom_i$: number of times that feasible site *i* has been classified in class `Recommended`;

$Accept_i$: number of times that feasible site *i* has been classified in class `Acceptable`; and

$Unaccept_i$: number of times that feasible site *i* has been classified in class `Unacceptable`.

Accordingly, a site i with $Recom_i$ = 18; $Accept_i$ = 14 and $Unaccept_i$ = 19 will belong to the `Unacceptable` class for wind farm siting in the "social" classification. Likewise, a site j with $Recom_j$ = 8; $Accept_j$ = 11 and $Unaccept_j$ = 32 will belong to the same class.

Clearly, there are greater controversy associated to the "social" classification of site i than associated to the classification of site j. To take this aspect into account, it was decided to accompany the "social" classification of feasible sites by an indicator of the degree of controversy. This indicator has been constructed as:

$$\text{degree of controversy}_i = 1 - \frac{\left|2 * Recom_i + Accept_i - 2 * Unaccept_i\right|}{2 * Recom_i + Accept_i + 2 * Unaccept_i} \qquad (8)$$

This formula yields a degree of controversy that varies between 0 and 1. A value of 0 means that all participants have assigned the feasible site i to the same class, i.e. there is an absolute consensus on this feasible site classification. A value of 1 indicates an even split of perspectives amongst participants - an equal number classified the feasible site i in the categories `Recommended` and `Unacceptable`. Coefficients in the formula have been thought to position competing views on opposite sides (positive and negative) and give stronger weights to more extreme positions. This justifies why $Accept_i$ appears in the formula with a unitary coefficient while $Recom_i$ and $Unaccept_i$ have a double weight.

The "social" classification and the accompanying degree of controversy will highlight the sites where consensus with regard to wind farm siting exist and where controversy exists. This can stimulate debate around particular sites. For examples, opponents to locating a wind farm in a site "socially" classified as `Recommended` will be tempted to voice their arguments against. Moreover, the realisation of differences between the individual's views and the general public opinion may trigger reconstruing (and eventually revision of initial opinions) and encourage debate (*cf.* section II.4.4).

To make it easier for the participant to compare their personal classification of feasible sites with the "social" classification (and associated controversy map), it was decided that the former (if the participant has created one) should be loaded and displayed alongside the latter in the AM's map viewer.

V.5.3. Logical model

Figure V.38 shown the logical model underpinning Keβler's prototype.

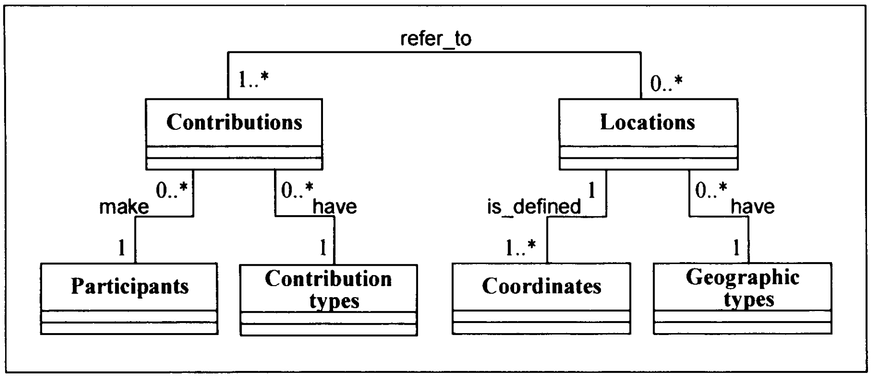


Figure V.38 – Logical model underpinning Keβler's prototype [adapted from Keβler (2004)].

There are two central entities: 'Contributions' and 'Locations'. These are related by a many-to-many relationship, meaning that a contribution may *refer to* none or various locations and one location has to be *referred to* by at least one contribution. A discussion contribution is *authored* by one participant exclusively, but a participant can *author* various contributions. Each contribution *has* a particular type (Keβler proposes five types: question, suggestion, argument pro, argument contra or neutral statement). Finally, locations are *defined* by at least one set of pair of coordinates (*x* and *y*) and *have* a geographic type associated: point, line or polygon. On the other hand, coordinates must contribute to the definition of a location to exist.

V.5.4. Structural design and content overview

Keβler's prototype consists of an Java Applet that can be embedded in any webpage. Therefore WePWEP's third tier includes two main pages: one introducing the tier and what can be done on it, and the following embedding the Applet, Figure V.39.

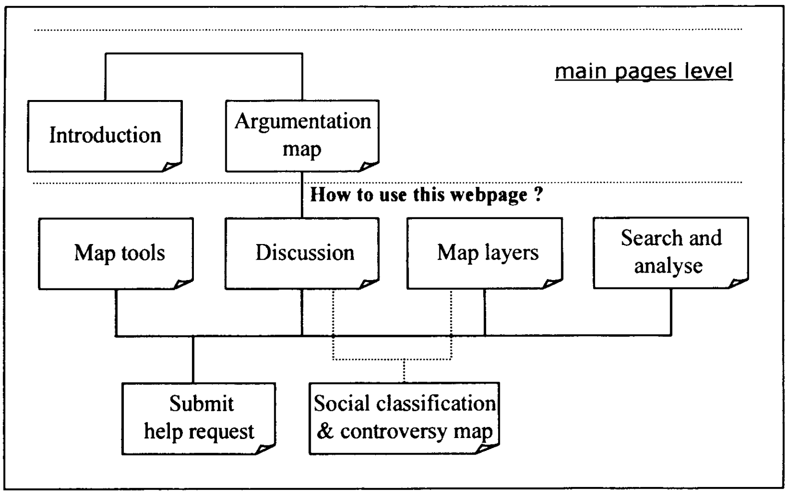


Figure V.39 – Structural design of WePWEP third tier.

A posteriori (*cf.* section VII.2.3, sub-section Test outcome), a set of secondary webpages were added to the tier – those included in the grey box in Figure V.39. The added pages provide information on the tools available in the AM, how to use them, how to control the visibility of thematic map layers, and the meaning of the colours appearing on the map (e.g. selecting colours for specific map layers) among other aspects.

V.6. Fourth tier: receiving feedback

The fourth, final tier was conceived to realise the use case 'Evaluate the system' (*cf.* section III.2.4). It fundamentally consists of a questionnaire designed to obtain user feedback.

V.6.1. The questionnaire

The questionnaire was designed to: (1) gain perspective on individual gains from using the system; (2) acquire opinions on the implemented prototype, namely on the usefulness of available functionalities, difficulties experienced and suggestions for improvement; (3) know whether or not the participant has found the system a learning-enhancing framework for participating in spatial planning; and (4) gain insight into specific aspects and assumptions behind the system's conception and design (e.g. whether the public should be involved in the planning process and whether a participation system should provide information alongside collecting views). Note that views on the planning problem at hand are not sought.

Literature reviewed did not show a "questionnaire-type" to gain feedback on the intended aspects. Therefore, the questionnaire was designed based on two resources: the principles for designing surveys presented in Czaja and Blair (1995) and the feedback questionnaire of the OSDM systems (Carver *et al.*, 1996; Carver *et al.*, 2002b).

The questionnaire is organised in four sections. The first section, entitled "Your gain after using the website", aims at assessing the extent WePWEP contributed to learning. The second section is entitled "Your opinions on the website" and seeks opinions on the implemented prototype and suggestions for future improvement. The third section is inspired in the OSDM systems' questionnaire. It is named "Your view on public participation issues" and collects data to ensure (or contradict) assumptions underpinning this research, such as "the public should be involved in strategic planning". Finally, the last section collects the participant's perception on the time spent using the system and how knowledgeable s/he is of the case study area. These aspects were considered relevant to interpret data on the participant's perception and usage of the system.

The questionnaire includes a mix of close-ended and open-ended questions. The former enable a quantitative evaluation of the system; the latter try to capture details of, or reasons for, responses to close-ended questions. Close-ended questions were developed with response categories. For example, "yes/no/don't know or don't have an opinion" or a point scale varying from 1 to 6. In this case, the extreme points are coded depending on the question (e.g. 1 means "very little" and 6 "too much"). An even-point scale was selected to avoid neutral responses. This way, the participant is "forced" to take a position, whether slightly on the positive side or on the negative side.

V.6.2. Testing and improving the questionnaire

The final version of the questionnaire was achieved after two cycles of "testing-improving", conducted in different occasions. Each testing involved uniquely one respondent (a different PhD researcher each time) and consisted of a think-aloud interview followed by a debriefing (Czaja and Blair, 1995). The first test led to a considerable number of changes, namely regarding the questions' wording and their presentation sequence. The improved questionnaire was submitted to a second test. Only a small number of comments were obtained this time. Therefore, after incorporating relevant changes, the resulting questionnaire was considered ready for feedback collection. The final questionnaire can be consulted in Appendix A, Figure A.2.

V.7. Linking it all together

In spite of its four tiers, WePWEP must be a whole system; a seamless environment (*cf.* section III.3.4). This section deals with design aspects that concern the system as a whole.

V.7.1. WePWEP introduction

WePWEP is a system that will exist over the Internet. To access it, the participant has to type the WePWEP's URL in the web browser, and, in this case, it is likely that s/he will know what will encounter. But opportunity exists for web users to come across WePWEP while searching topics related to wind energy or spatial planning. This justifies the creation of an introductory page to the system, which was established as a system's requirement.

Design-wise, WePWEP introduction was conceived as two webpages. The first page welcomes the user, introduces the initiative leading to the system development and briefly explains what can be done within it. The second page gives an overview of the system, addressing, in particular, its structure and fundamental aspects for its usage, such as navigation and registration. Splitting the introduction over two pages enables lighter, shorter webpages, preferable from the usability and readability points of view.

V.7.2. WePWEP navigation

As stressed, WePWEP should consist of a flexible working environment: participants should be able to jump easily from one tier to another, and between pages of the same tier, in search of information or to revise entered contributions.

A cross-tier navigation menu, persistent throughout WePWEP, was chosen to implement flexibility in navigation. This menu was designed to display a tab for each tier, which will give access to it, and, for the current tier, display all main pages integrating it, working as links to the respective page. To facilitate navigation, in particular to those less familiar with the Internet, a parallel navigation mechanism was conceived: the traditional "Next" and "Back" buttons will be located at the bottom of each webpage to drive the participant throughout the system.

V.7.3. User registration and login

Motivated by security issues, user registration was set a requirement for WePWEP (*cf.* section III.3.6). The typical registration/login procedure was adopted for WePWEP: unregistered participants login by registering themselves with the system (this automatically logs in the participant); registered participants will have to provide the registered username and password to login; if the participant mistypes either the username or password, a "problem solve page" will be displayed asking for re-typing the authentication data or request a new password to be sent to the registered email; after logging in with a sent (computer-generated) password, the participant is invited to re-set the password to a more memorable one.

Strategically, it was decided to require registragion/login only to participate actively in the planning process (i.e. create a classification of feasible sites in the second tier or contribute to the debate in the third tier). This way, WePWEP is left open as an information resource (note that informing the public is already a level of participation, *cf.* section II.6.3) and can captivate potential participants.

As a participation system, WePWEP should encourage people to express their views. In terms of design, this idea is achievable by enabling/encouraging login on each WePWEP main webpage. Two other design-related aspects were decided for WePWEP. First, to avoid excluding from participation individuals that do not have an email account or are not interested in providing it, an email address will not be required during registration. Nevertheless, participants will be encouraged to provide one (if they have one) to enable a new password to be sent to them in case they have forgotten their registered password; otherwise a new registration will be required. Second, after logging in, returning participants will be asked if they want to return to the page from where they logged out on their last visit. This encourages the participant to retake their participation process and, at the same time, optimises the time spent in WePWEP.

With the purpose of finding out the type of people that are interested in WePWEP and testing assumptions commonly associated to wind energy (such as NIMBYism), it was decided to extend the user registration beyond asking the minimal information necessary for the authentication process (i.e. username and password). A questionnaire was designed to collect some personal details (such as gender, age, address postcode, residential status, etc.), knowledge status and perception on wind energy technology (e.g. major concern related to wind energy), and familiarity with computers and the Internet. These aspects were considered potentially relevant to analyse the participant's usage and assessment of the prototype and find out possible correlations between the participant's profile (e.g. age or computer literacy) and their assessment of the prototype.

The registration questionnaire was developed (and tested) in the same moulds as the feedback questionnaire (*cf.* sections V.6.1 and V.6.2). It can be seen in Appendix A, Figure A.1.

V.7.4. Collecting data about WePWEP usage

The WePWEP use case 'Examine usage of the system' (*cf.* section III.2.5) requires the system to capture and store data about the usage that each participant makes of it (*cf.* section III.3.4).

Three types of data were considered relevant to collect:

- information on the visited pages and respective sequence;
- time spent on each page; and
- actions executed on each page.

The usefulness of these datasets can be illustrated by the following hypothetical situation: a participant submits a comment stressing that a certain aspect has not been taken into account during the problem structuring; looking at this comment, the analyst realises an incongruence as s/he knows that the aspect mentioned by the participant has indeed been considered; having the possibility to reconstruct the participant's route within WePWEP, the analyst can do so to conclude whether the participant has missed the page addressing this aspect, whether the page has not aroused the participant's interest (the time spent on the page is considered a proxy for the webpage interest[40]), or whether the participant has misinterpreted given information.

[40] This implies that a distinction cannot be made between participants with no real interest on what is discussed on the page and those who already know, or think to know, the information presented.

This data can also constitute a rich resource for prototype improvement. For example, it can hint that access to certain pages is not clear (many participants "missed" it) or that information should be presented in a more attractive way to capture the participant's interest/attention (many participants move out rather quickly). The sequence of visited pages can also provide information on connections between pages that can/should be established (via hypertext links) to facilitate WePWEP navigation.

Figure V.40 outlines the logical model underlying the process of usage data capture. A participant, working within a session, *executes*, at least, one action (visit/request their first page of the system) and can execute any number of actions (cardinality '1..*' nearby the 'Possible_actions' entity box); and a possible_action may exist without *having ever been executed* by any participant (session), or may *have been executed* by any number of participants (cardinality '0..*' nearby the 'Sessions' entity box). Note that this logical model implies that possible_actions within the system are pre-defined. Note that 'Sessions', instead of 'Participants', are used in the logic model because their reference is unambiguous within WePWEP implementation, conversely to 'Participants' (*cf.* section VI.5).

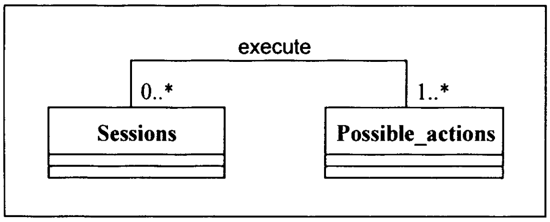


Figure V.40 - Logical model underlying data capture on the participants' usage of the system.

V.7.5. The overall logic model

Figure V.41 puts together the logical model developed for each tier and provides an overview of WePWEP as an integrated and cohesive system.

It is worth explaining why 'Participants' and 'Profiles' are two different entities. As noted in section V.7.3, a participant can use the system without being logged in; hence a participant can exist without having a profile associated. This is translated in the '0..1' cardinality of the relationship 'Profiles' – 'Participants', beside the entity 'Profiles'.

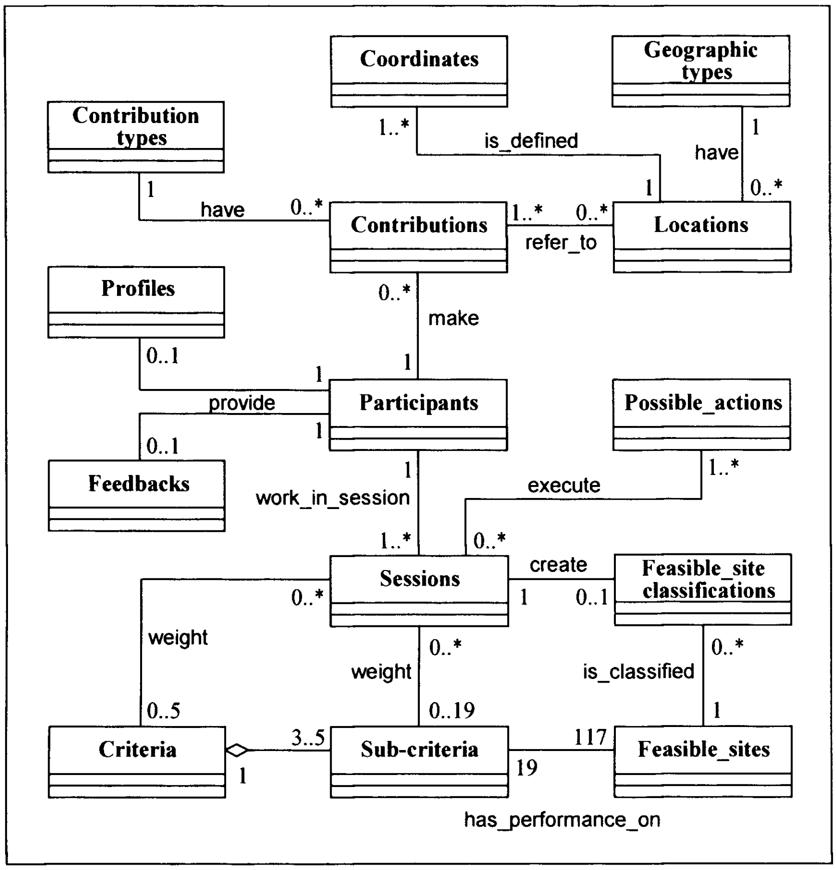


Figure V.41 – WePWEP's overall logical model.

V.7.6. The overall structural design

Figure V.42 (next page) depicts WePWEP's overall structure. Plain lines represent connections between webpages via navigation menu; dashed lines represent connections via hypertext links. A small, grey entry form on the left upper corner of some webpages' representation means that these pages request some type of input from the participant (e.g. criterion weight for decision-making).

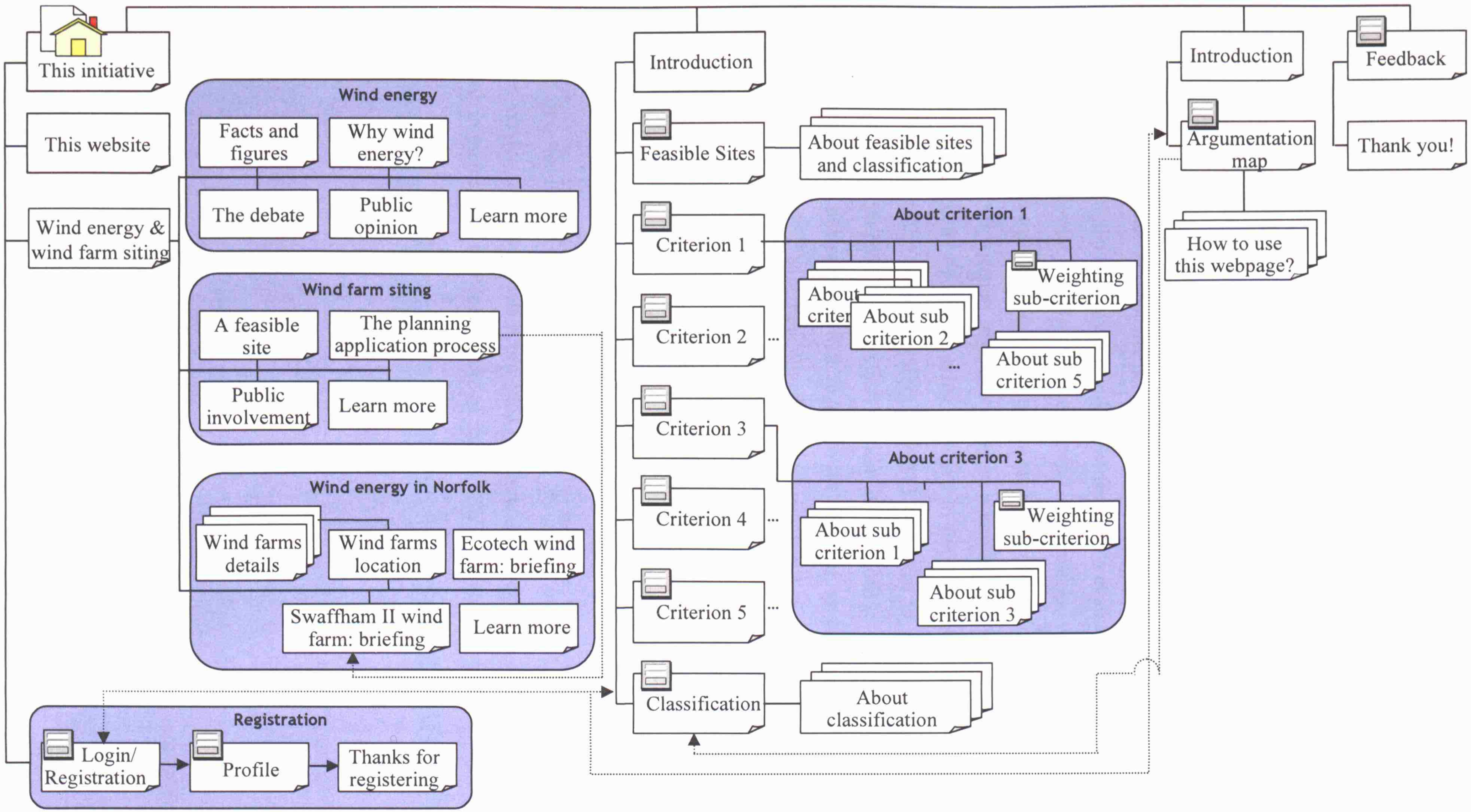


Figure V.42 – WePWEP's overall structural design.

V.8. Summary

Throughout this chapter the proposed conceptual framework is developed into an application to be implemented in a web-based environment. Due to the selected spatial planning problem and the implementation environment, the application was named WePWEP – Web-based Participatory Wind Energy Planning.

WePWEP comprises four tiers: one tier per module of the proposed conceptual framework and a fourth one dedicated to the framework's and implementation's evaluation. In the first tier, three topics were found relevant to address in the system: wind energy, wind farm siting and wind energy projects within the study area (county that includes it). For the second tier, the strategic planning of wind farms location was structured as a sorting problem. Nineteen evaluation-criteria were identified for decision-making, grouped in five 'factors'. The user of the system (i.e. the participant in the spatial planning problem) will have to weight the five factors to generate a planning proposal, i.e., a classification of the feasible sites for wind farms into suitability classes for this purpose. With regard to the third tier, an existing AM was chosen to be embedded in WePWEP as it streamlined the implementation work. The selected AM offers most of the functionalities required for WePWEP; however, a few modifications had to be made in the AM's code to implement, for instance, the concepts of "social planning solution" introduced in chapter III (*cf.* section III.2.3). Finally, aspects concerning the development of the feedback questionnaire to evaluate the proposed framework are discussed as well as aspects regarding WePWEP as a cohesive and integrated system.

For each tier, the logical model and the structural design are outlined. Towards the end, an integrated version of these models is provided to enable an anticipation of how the system will look once implemented. Implementation of the WePWEP prototype is tackled in the next chapter.

Chapter VI

WePWEP implementation

VI.1. Introduction

This chapter focuses on the implementation of the prototype developed over the previous chapters. It is structured in twelve sections. Section two introduces the achieved WePWEP implementation by means of a guided tour. Section three describes the system's architecture. Section four discusses enabling technologies and presents the choices made. Section five describes how the alphanumeric database has been implemented; and the next four sections (from six to nine) report on the implementation of the four tiers of WePWEP. The most relevant functionalities are reviewed and fundamental implementation details briefly explained. Section ten also addresses implementation aspects, but regarding cross-tier requirements and the system as a whole. These sections are not intended to be an implementation manual, but rather to give an idea of what is behind the achieved implementation. Section eleven discusses the achieved implementation and contrasts it with an ideal one and, finally, section twelve concludes the chapter with a summary of the information presented and a highlight of the most relevant aspects.

Before proceeding, it is important to note that WePWEP was developed as a prototype (proof-of-concept) and it should be envisaged as such. In fact, as stated earlier, the fundament behind WePWEP development is to investigate to what extent the framework proposed in Chapter II, section V, enhances learning.

VI.2. WePWEP guided tour

This section offers a feeling of how WePWEP looks to its users. A maximum of four screenshots, accompanied by short explanations, are provided to describe each tier. Screenshots presented are of the final version of the system.

WePWEP's home page introduces the context in which it has been developed and tells the user what can be done within the system. The following page, Figure VI.1, presents the system's structure and provides basic information on how to use it.

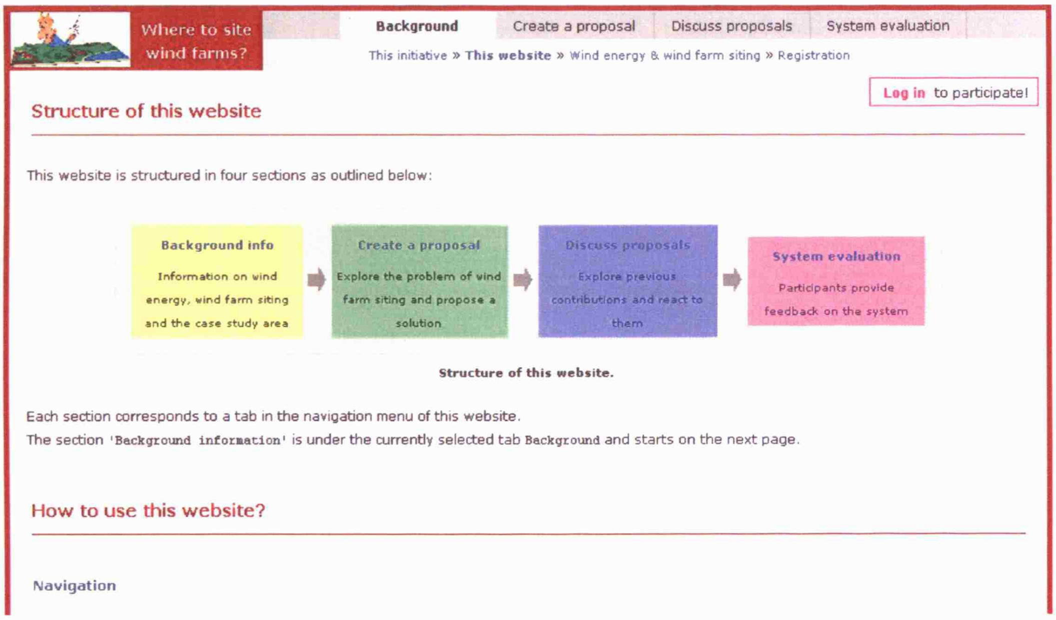


Figure VI.1 – WePWEP introduction: the system's four-tier structure is explained and information is given on how to use the website (partial screenshot).

The next page, Figure VI.2, is the information portal corresponding to the main page of WePWEP's first tier (*cf.* Figure V.1). From here the participant can access information on the topics covered: wind energy, wind farm siting and wind energy in Norfolk, the county including the case study area.

Information is presented in various formats. Figure VI.3 shows factual information on wind energy displayed in bullet points, while Figure VI.4 shows information displayed in tabular form and on a map.

Note that, in Figure VI.3, hypertext links are provided to access to information sources (light blue, superscript numbers at the end of each bullet point). This is a practice used throughout WePWEP to enable users to make their own mind regarding the credibility of information presented and investigate further, if interested.

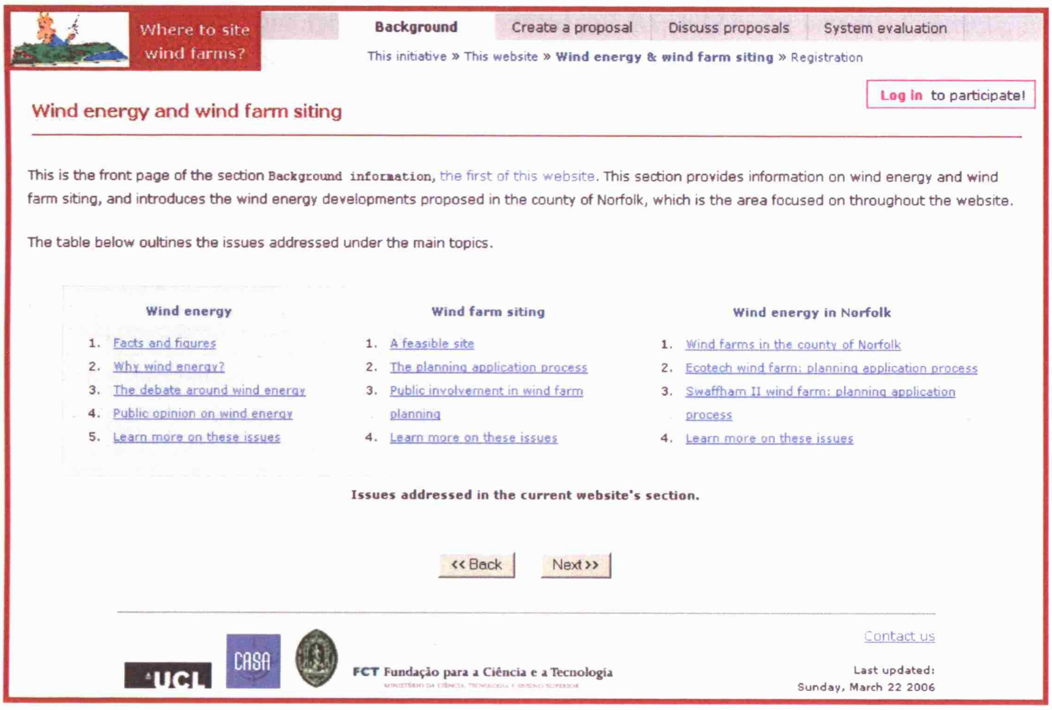


Figure VI.2 – First tier: information portal.

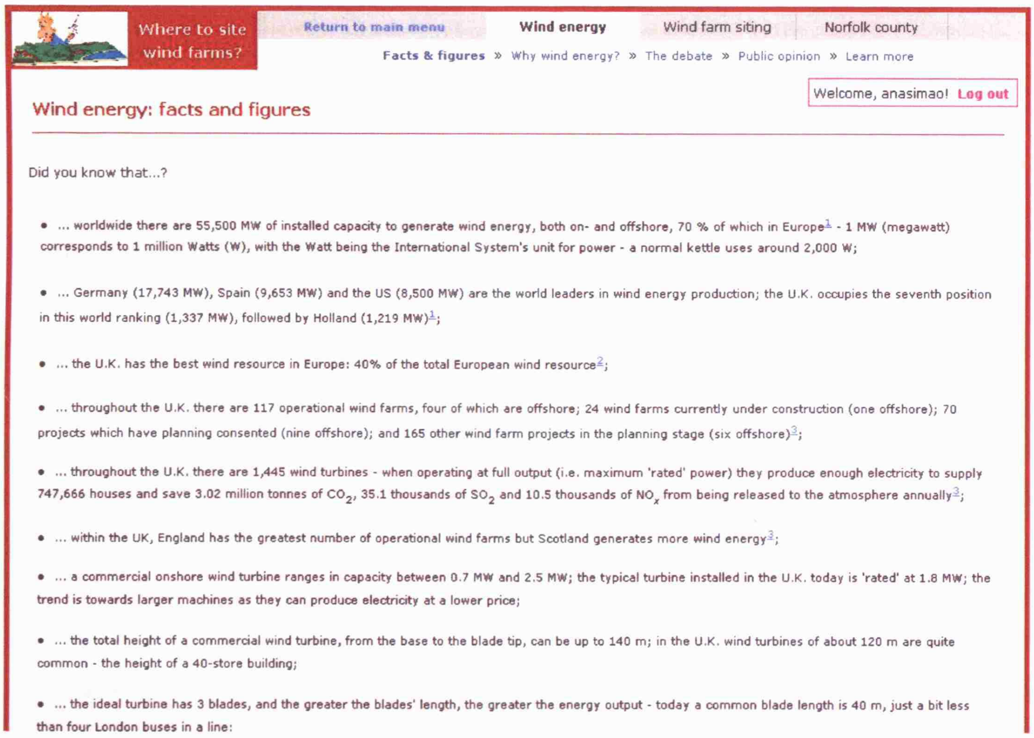


Figure VI.3 – First tier: Factual information on wind energy (partial screenshot).

Figure VI.4 is an example of a page under the topic 'Wind energy in Norfolk'. In common with other pages under this topic, it provides details (location and characteristics) on operating, approved and refused wind farm projects submitted to LPAs within the county of Norfolk. For refused wind farm projects, a briefing of the application process is provided and the reasons for refusal identified. Information on the local wind farm projects was gathered from various sources and is compiled in Simão (2006b).

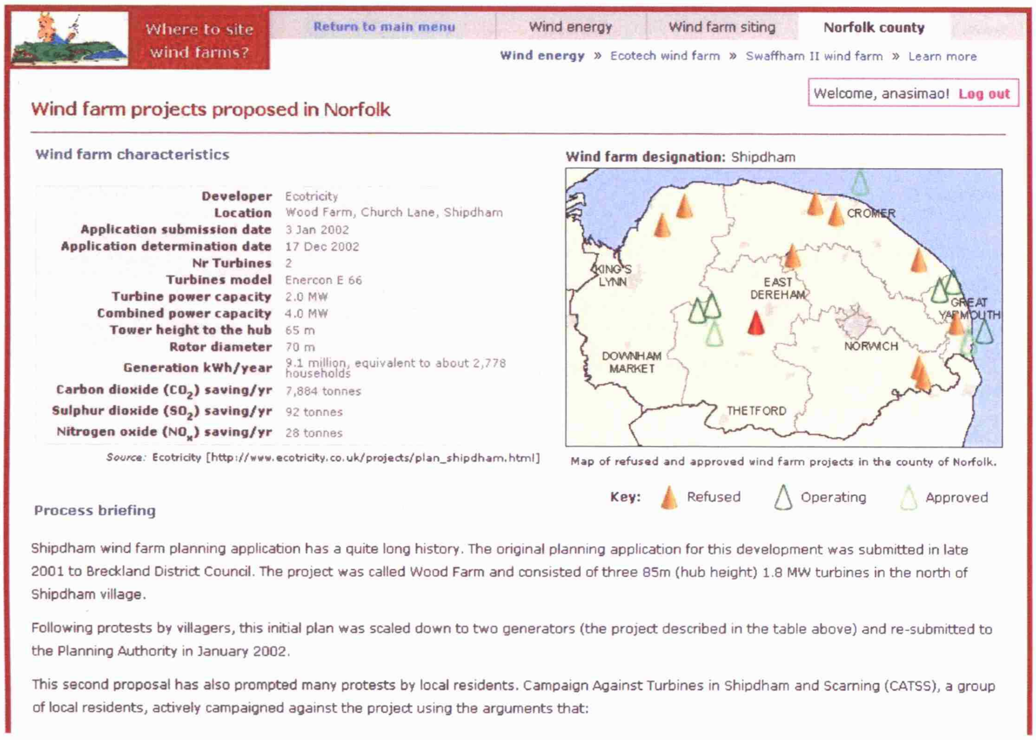


Figure VI.4 – First tier: information on the refused Shipdham wind farm project, marked in red on the map (partial screenshot).

In the second tier, after an introductory page that explains how the user can contribute to the planning process using WePWEP, the participant is asked for a first contribution: to select the most important criterion for decision-making amongst those available, Figure VI.5.

Pressing the "Next" button brings up the webpage addressing the criterion selected as the most important one, Figure VI.6. This page explains that performances on this criterion ('Local Impact' in the current example) are assessed based on three aspects, noise disturbance, shadow flicker effect and impact on property value - which are the "sub-criteria" under the "criterion" 'Local Impacts' devised during problem structuring (*cf.* Figure V.6) - and that the overall performance of each feasible site on the criterion is depicted on the map on the right hand side. Furthermore, it teaches that the remaining decision criteria should be weighted having the importance of this one (the most important criterion) as reference.

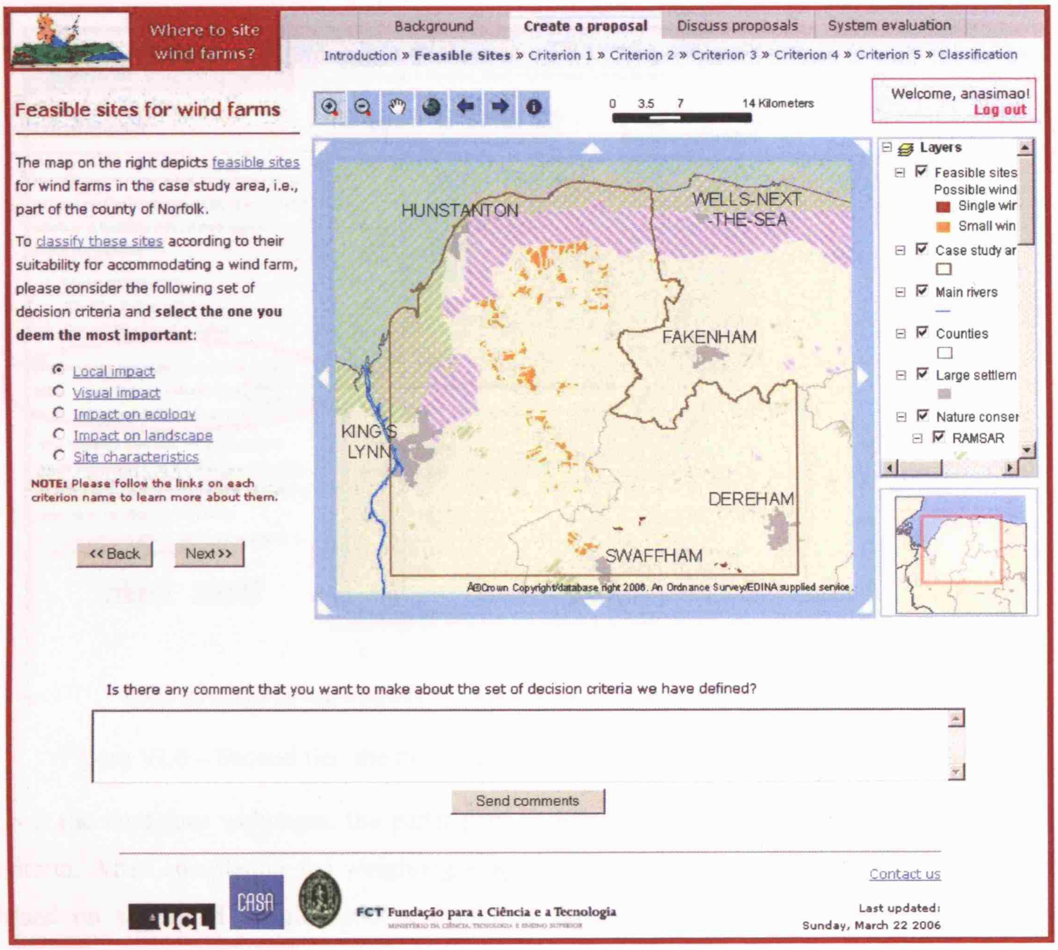


Figure VI.5 – Second tier: selection of the most important criterion for decision-making.

In Figure VI.6, within the red, oval form, the text "overall local impact" appears as a hyperlink. This hyperlink leads to the webpage where the default weights of sub-criteria used to compute the overall performances on the current criterion can be changed, Figure VI.7.

In Figure VI.7, the "Return" button (top left corner) brings the participant back to the sequence of the tier's main pages (*cf.* second line of the navigation menu in Figure VI.6).

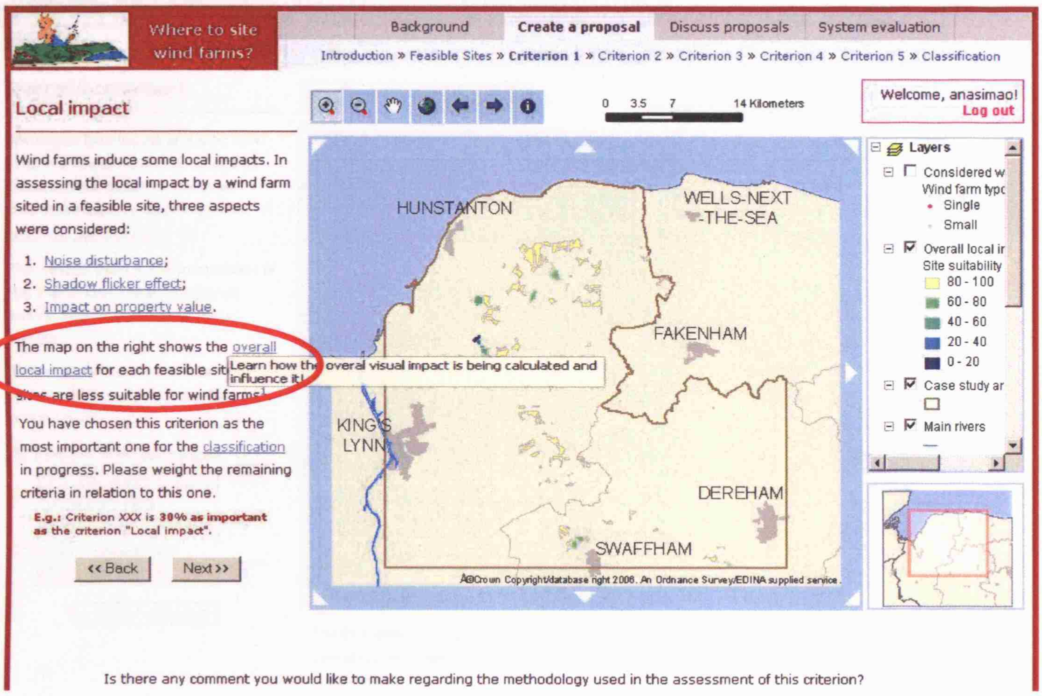


Figure VI.6 – Second tier: the most important criterion webpage (partial screenshot).

Over the next four webpages, the participant is asked to weight the remaining four decision criteria. After completing the weighting stage, a classification of feasible sites is generated based on submitted weights and is displayed for inspection/analysis, Figure VI.8. If the participant is not happy with the resulting classification, s/he can revise the submitted weights (using the form on the left of the map) and press the button marked "Submit weights" to generate a new classification.

The toolbar on top of the map viewer in Figures VI.5 to VI.8 enables the user to interact with the map, for instance, zooming into areas of interest. Figure VI.8 shows a zoomed in image. Note that the backdrop information layer has changed from the beige colour to display a raster image of the local area.

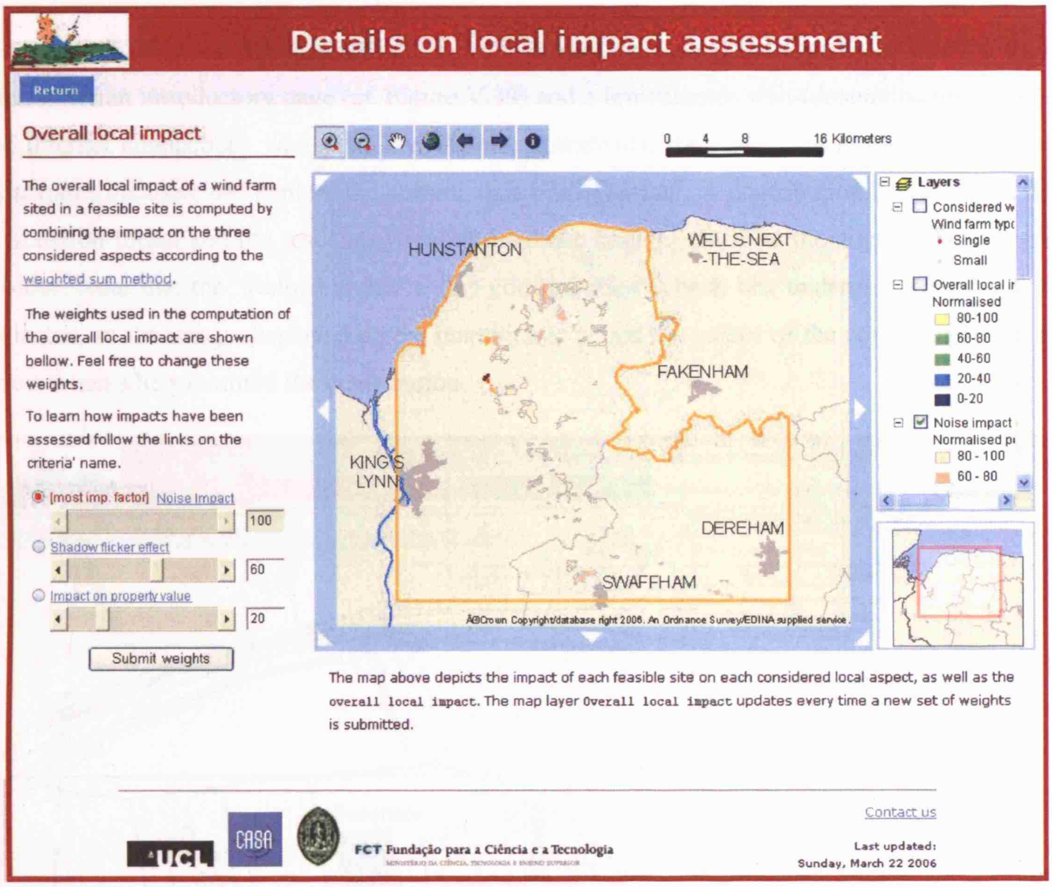


Figure VI.7 – Second tier: default weights (and types) of sub-criteria can be changed.

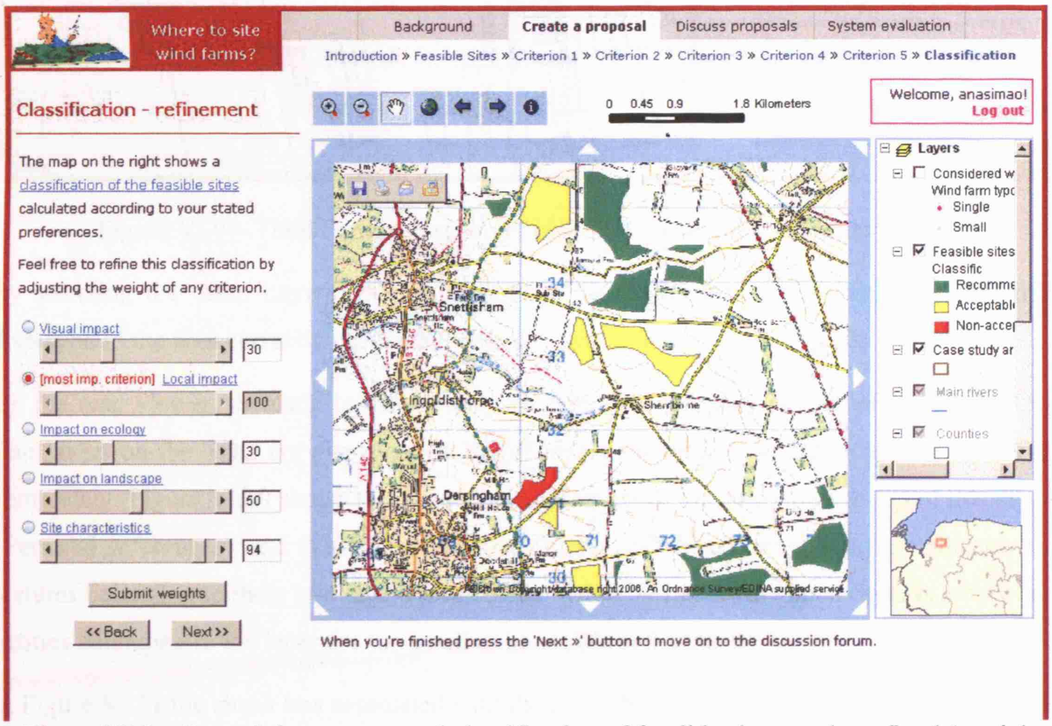


Figure VI.8 – Second tier: a generated classification of feasible sites can be refined (partial screenshot).

The "Next" button on the 'Classification – refinement' webpage (Figure VI.8) leads to the third tier. After an introductory page (*cf.* Figure V.39) and a few minutes wait (depending on the type of Internet connection) while the Java Applet downloads, the AM is displayed. Figure VI.9 illustrates the use case 'explore the current state of discussion'. A contribution is selected in the discussion forum and the associated spatial reference is highlighted on the map, in dark purple colour. Note that the "Reload author's map configuration" check box underneath the forum is selected, so the image displayed on the map viewer is that the author of the contribution had in view when s/he submitted the contribution.

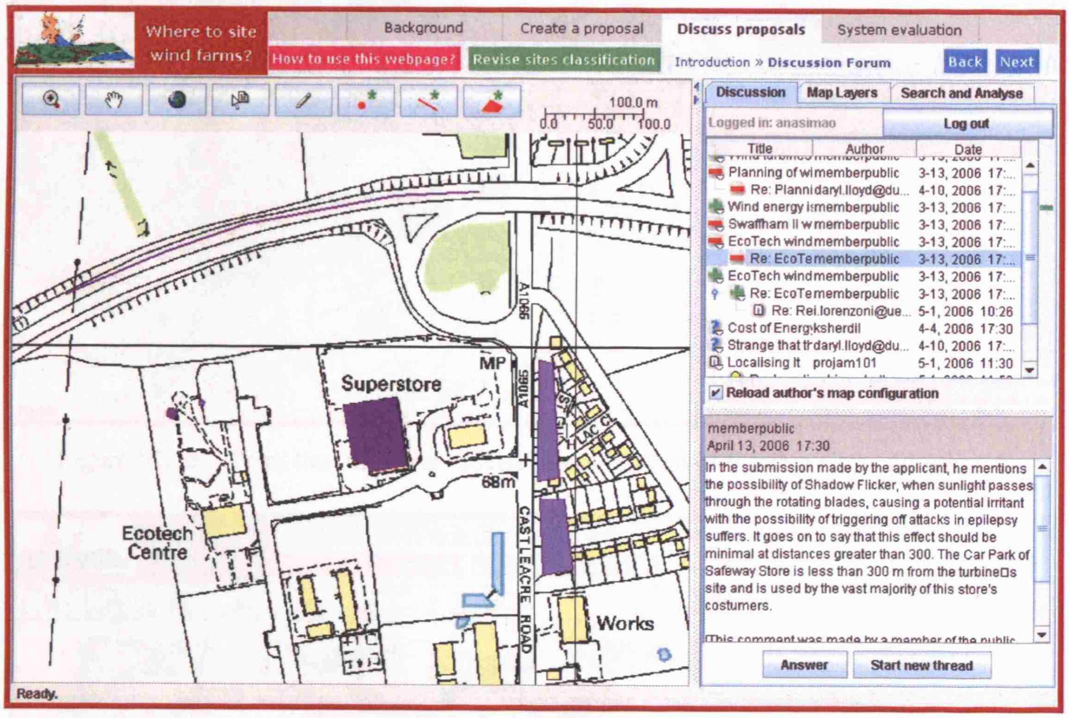


Figure VI.9 – Third tier: exploration of contributions in the discussion forum.

By selecting the 'Map Layers' tab, on top of the discussion forum, the TOC/map legend is displayed in the area currently occupied by the discussion forum, Figure VI.10.

On the map viewer, thematic layers are displayed in the order they are arranged in the TOC. Top layers on the TOC are displayed on top of layers shown below, hiding them partially or completely. Figure VI.10 shows the "social" classification of feasible sites (on top of this layer, "Personal references" and "Other participants' references" layers are displayed; however no features belonging to these two layers are actually visible because the former layer is empty and entities belonging to the latter are too small to be visible at the current scale).

In Figure VI.11 the check box associated with the layer 'Social classification of feasible sites' is unchecked in the TOC. This means that this layer is not shown on the map viewer and the next layer, 'Controversy associated with social classification', is visible. Before the latter was completely hidden by the former because both layers contain the same spatial entities – the feasible sites.

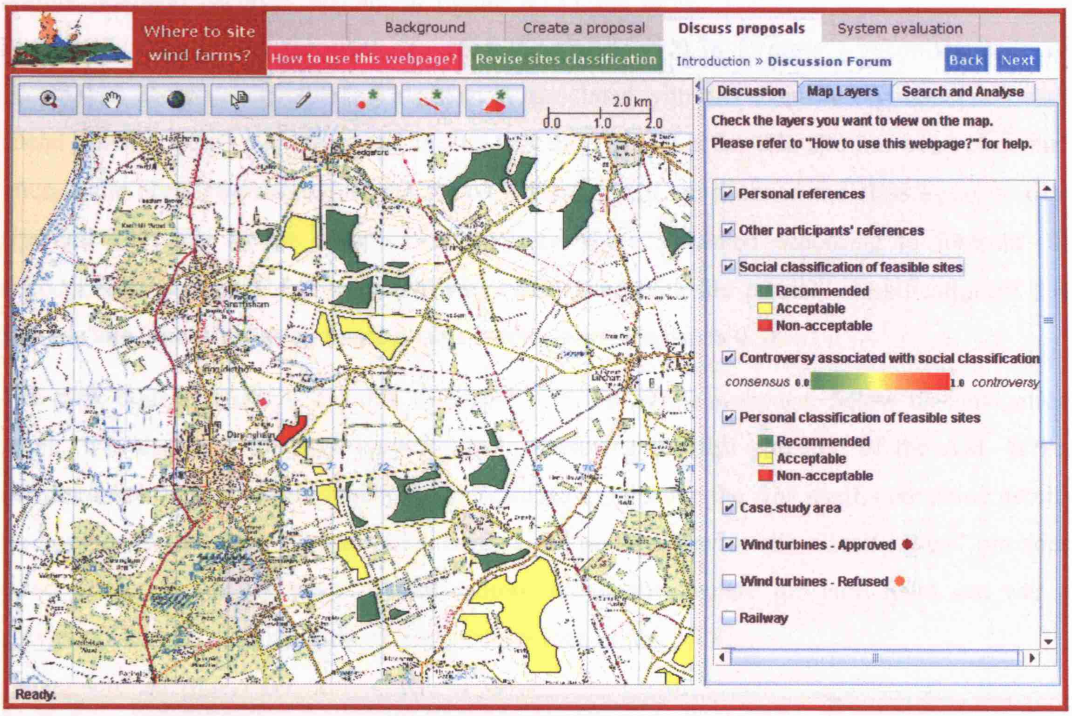


Figure VI.10 – Third tier: the layer "social" classification of feasible sites is displayed.

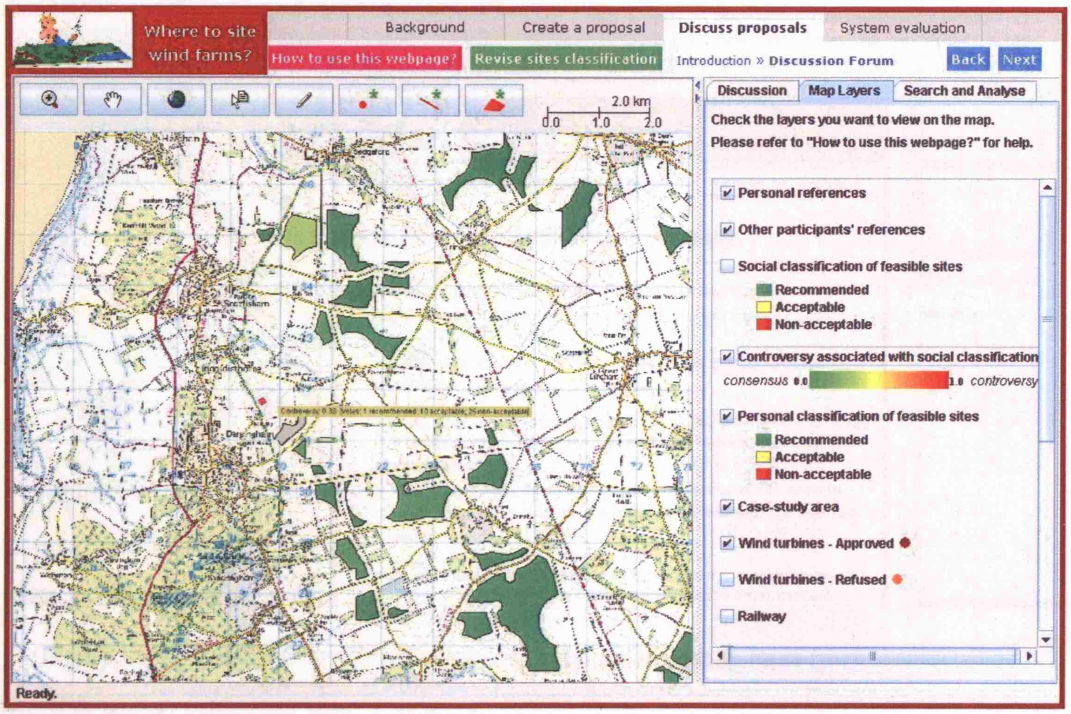


Figure VI.11 – Third tier: the controversy layer associated with the "social" classification of feasible sites is displayed.

In the map viewer, whenever the mouse cursor moves over a map feature, it changes colour (appears in the selection colour) and a label (which depends on the map layer to which the feature belongs) becomes visible. In Figure VI.11 the mouse cursor is over a feasible site, displayed in grey, and the user can read 'Controversy: 0.38 [Votes: 1 recommended, 10 acceptable; 25 non-acceptable]'. This label is associated with the 'Controversy associated with social classification' map layer and means that this particular feasible site has been classified once in the class `recommended` site for wind farm siting, ten times in the class `acceptable` site and 25 times in the class `unacceptable` site. Calculated according to formula (8) introduced in section V.5.2, the controversy associated with the "social" classification of this feasible site (classified as an unacceptable site for a wind farm) is 0.38.

The pink button "How to use this webpage?" on top of the webpage, below the navigation menu, was designed to assist participants in exploring the full potential of the AM. When activated, it brings up a set of webpages, organised in tabs like the AM itself, containing details on how to use the AM, Figure VI.12. Beside, the button "Revise site classification" provides direct access to the webpage 'Classification- refinement', where the participant can edit a previously created classification of feasible sites (see Figure VI.8).

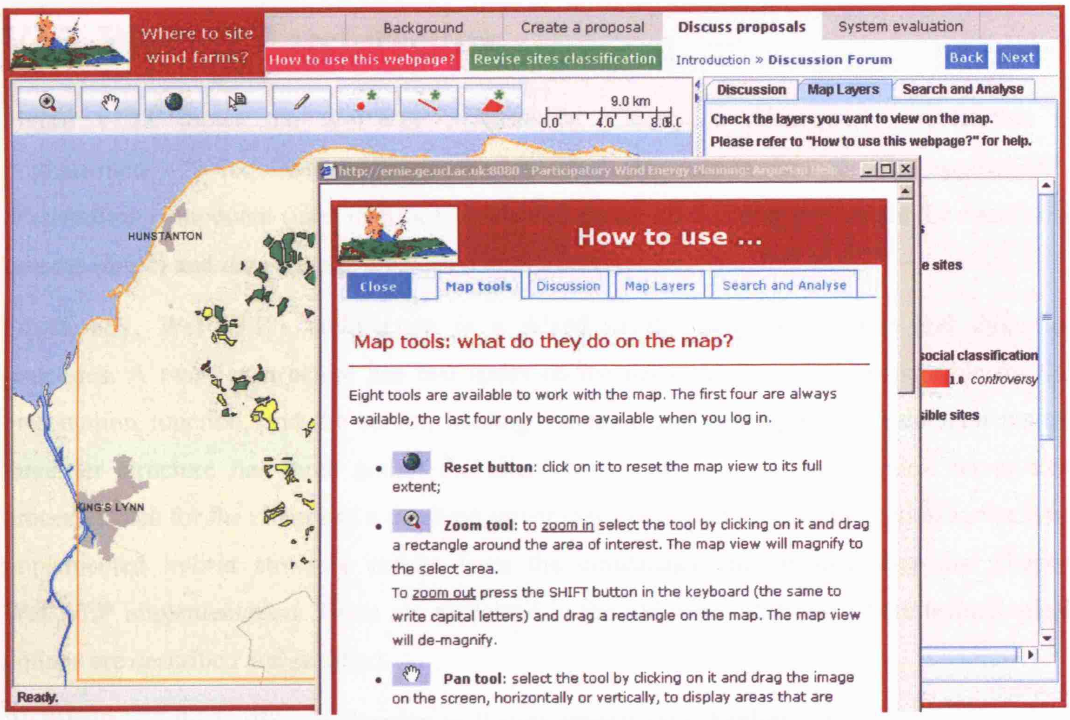


Figure VI.12 – Third tier: help on using the argumentative map tools (partial screenshot).

Pressing the "Next" button brings up the feedback questionnaire that constitutes the fourth tier, Figure VI.13. Here, the participant is asked to provide feedback on their experience using WePWEP and whether s/he thinks it is, indeed, a learning-enhancing system.

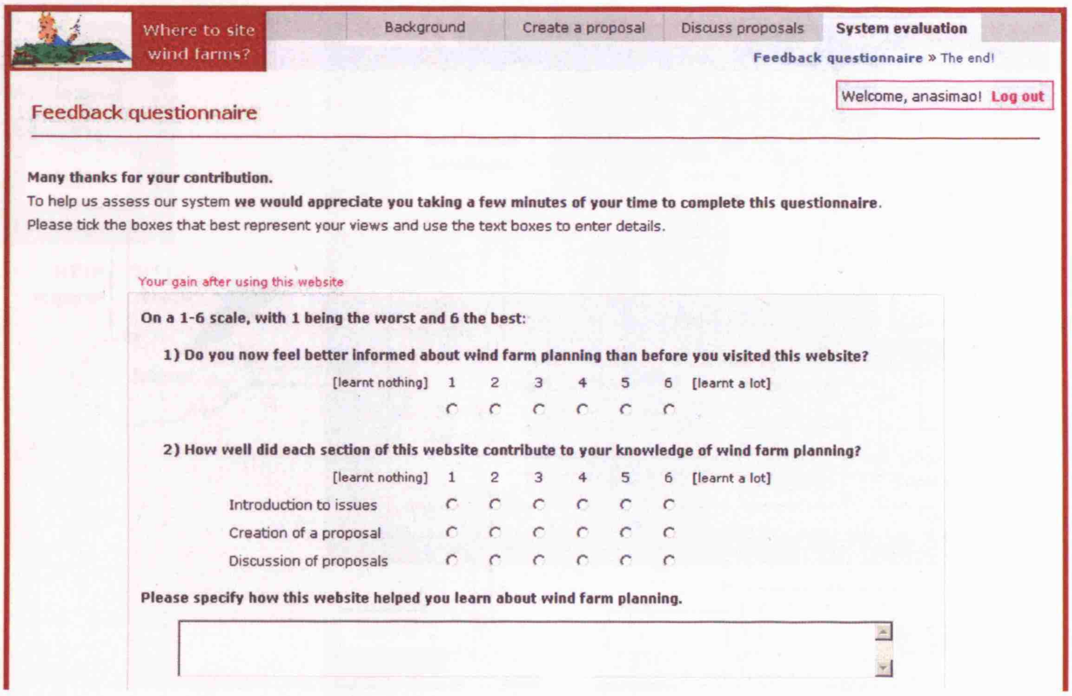


Figure VI.13 – Fourth tier: feedback questionnaire (partial screenshot).

VI.3. WePWEP architecture

Figure VI.14 shows the WePWEP architecture. Clearly, a *client-server* architecture is implemented – a requirement previously identified (*cf.* section III.3.5). The application's *presentation* component (user interface) is located on the client computer, while the functional process (*logic*) and *data* storage are hosted on the server.

Structurally, WePWEP's architecture is a mixed of the classical two-tier and three-tier structures. A two-tier structure has two nodes on the network: the client, responsible for the presentation function, and the server, holding the logic and data application components. A three-tier structure has three nodes: the client (user interface), the application server that processes data for the client and a database server that stores data for the application server. The implemented hybrid structure results from the constraints and opportunities that shaped WePWEP implementation. These are explained in the following sections, where technological options are described and justified.

WePWEP is a thick client application as it runs several Java Applets. As a website for public participation this solution is not ideal as it requires the client machine to have a Java-enabled browser or the user to have administration privileges to be able to install a browser plug-in (Java Virtual Machine (VM)) on their machine (*cf.* section III.3.5). However, it resulted from implementation constraints.

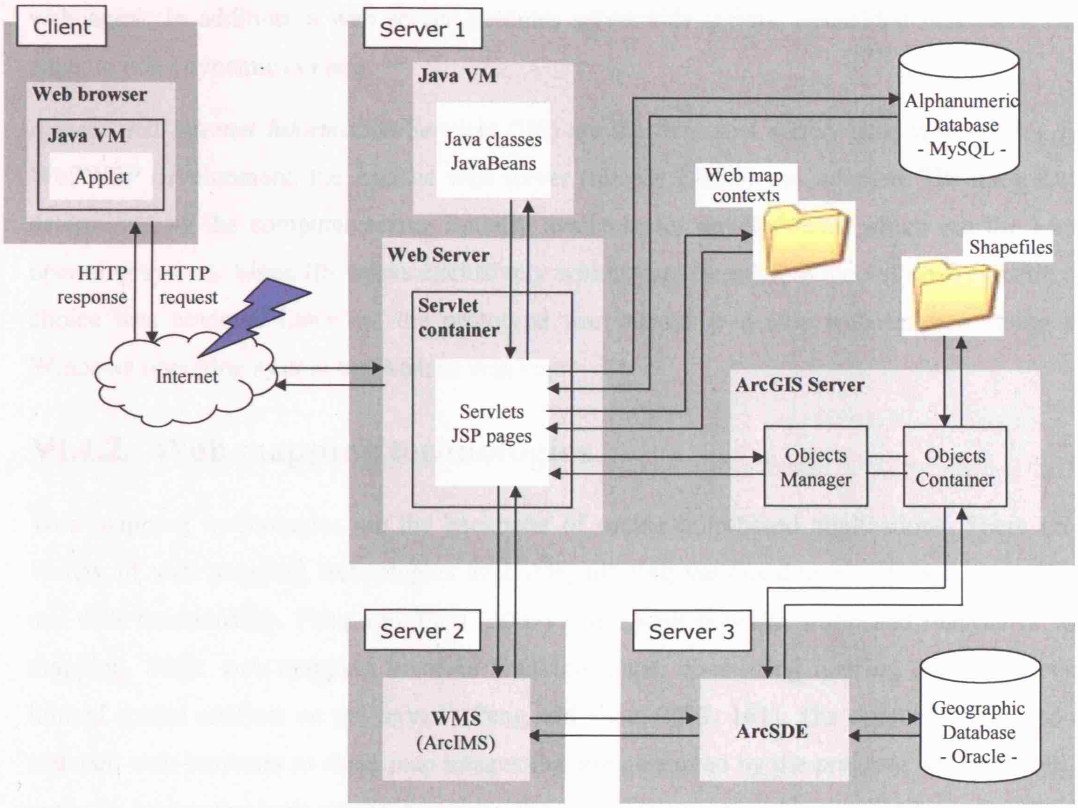


Figure VI.14 – WePWEP architecture overview.

VI.4. Technologies involved

As Figure VI.14 shows, WePWEP involves a significant number of technologies. For each specific functional requirement, a variety of enabling technologies were available, so decisions had to be made (some were constrained). This section briefly discusses some of these options and introduces the selected technologies. Key considerations for selecting amongst alternative technologies were:

- readily available;
- familiar to the author; and
- support rapid development.

VI.4.1. Web server

A web server is a core component for all Internet applications. Its major function is to accept HTTP (Hypertext Transfer Protocol) requests from clients (web browsers) and serve them HTTP responses, typically consisting of Hypertext Markup Language (HTML) documents (i.e.

webpages). In addition, a web server executes server-side scripts, embedded into the HTML page, to offer dynamic content.

Apache and *Internet Information Services* (IIS) are the two most widely used web servers. For WePWEP development, the Apache web server (release 2.0.54) was adopted. The choice was determined by the computer server initially available for development, which ran the Linux operating system. Since IIS works exclusively within the Microsoft Windows environment, the choice was obvious. Later on, the prototype was moved to a new web server running the Windows operating system but Apache was kept.

VI.4.2. Web mapping technologies

Web mapping technologies are the backbone of online map-based applications. There are a variety of web mapping technologies available, offering various degrees of user interactivity and GIS functionality. Peng and Tsou (2003) distinguish between *static* and *interactive* web mapping. Static web mapping involves "making maps, conducting queries, and doing some limited spatial analysis on the server" (Peng and Tsou, 2003: 161). The output is presented on standard web browsers as *static* map images that are generated by the program on the server. In contrast, *interactive* web mapping enables the system's user to select spatial features or draw graphics on map images. This is accomplished by client-side scripts, such as JavaScript, to make plain HTML dynamic and/or client-side applications like plug-ins, Active X controls, Flash and Java Applets. In general, more interactivity and GIS functionality are associated with more advanced technologies and more complex client/server architectures.

Both the second and the third tiers of WePWEP are map-based applications (*cf.* Chapters III and V). The selection of an appropriate technology needed to take account of both tiers' requirements. The second tier requires the web mapping technology to enable map navigation and exploration, and maps to be generated on-the-fly (e.g. to produce the classification of feasible sites based on submitted weights for the evaluation criteria). Since no web mapping technology, whether commercial or open source, enables the fulfilment of the latter requirement without resort to programming (as it is specific to the WePWEP application), ESRI software products were preferred due to previous familiarisation.

ESRI has two products that deliver maps and data via the Internet: ArcIMS and ArcGIS Server. ArcIMS is an Internet map server and provides browser-based access to GIS functionalities such as viewing, navigating and querying the map displayed[41]. ArcGIS Server is a platform for

[41] Additional functionality is possible if the ArcIMS Java Viewer is used, which requires a Java-enabled web browser. In contrast to the ArcIMS HTML Viewer, the Java Viewer permits the user to download

building server-side GIS applications and permits to deliver advanced GIS functionality (ESRI, 2004). This product comes with a web Application Development Framework (ADF) that includes a Software Development Kit (SDK) with software objects, web controls, web application templates, developer help and code samples, which facilitates the deployment of web applications.

The web ADF was the fundamental reason for choosing ArcGIS Server to implement WePWEP's second tier. Identical functionality could be achieved using ArcIMS, but more programming would be required as server objects and web controls, readily available in ArcGIS Server, would have to be programmed. It should be noted that the increased functionality of ArcGIS Server is reflected in the price of the software, which is significantly higher than the cost of ArcIMS. However, as University College London (UCL) has access, through CHEST (Combined Higher Education Software Team), to ESRI software at special discount prices, licence cost was not a major concern (the Geomatic Engineering Department was able to purchase a licence from CHEST). The ArcGIS Server version used for WePWEP development was 9.1, the most recent at the time.

The third tier involves Keβler's prototype (*cf.* section V.5.1). This prototype requires an Open Geospatial Consortium, Inc. (OGC)-compliant Web Mapping Service (WMS). Although ArcGIS Server 9.1 can serve as WMS, it does not support the OGC interoperability specification[42]. Therefore, another WMS was needed.

ArcIMS, the other software by ESRI, was the selected alternative. Although not an OGC-compliant WMS in itself, a WMS Connector was available that provided the interface between ArcIMS Map Services and OGC-standard WMS. This interface takes in OGC-standard WMS requests (in OGC-defined communication mechanisms - Extensible Markup Language (XML)) and translates them into ArcIMS's native XML requests (ArcXML or AXL), which are forwarded to the published Map Services, and, in an inverse procedure, translates back ArcIMS responses into OGC-standard responses, which are sent back to the client.

Hence, ArcIMS 9.1 and ArcGIS Server 9.1 were both used for the WePWEP implementation with different roles. In terms of the WePWEP architecture, these choices had some consequences. Since ArcGIS Server and ArcIMS cannot coexist on the same machine (they are incompatible), an additional server machine was required to implement WePWEP (*cf.* Figure VI.14).

features as vector layers (and not just images), which enables more robust selection options, buffering tools, and editing tools.

[42] The newer ArcGIS Server 9.2 version, released at the end of 2006, already supports the OGC interoperability standards (Maguire, 2006).

VI.4.3. Alphanumeric database server

WePWEP requires server-side alphanumeric data storage capabilities (*cf.* section III.3.5). Figure V.41, the WEPWEP's overall logical model (*cf.* section V.7.5), depicts the data structure and datasets required by WePWEP. While it is a relatively simple model, the amount of data that may need to be manipulated is potentially very significant. Each stored classification of feasible sites corresponds, in fact, to 117 records - one for each feasible site - and the number of WePWEP users can be quite large. This calls for an efficient way to store and retrieve data.

Database application programs have several advantages that make them suitable for implementing the WePWEP's logical model. These include (see, for instance, Hoffer *et al.* (2002) or Connolly and Begg (2004) for details):

- all data are stored in only one place;
- minimal data redundancy;
- improved data consistency;
- reduced data entry costs;
- improved data accessibility and responsiveness;
- improved data sharing; and
- independence from applications programs.

There are numerous database servers to choose from. One of the most popular is MySQL. This is an open-source, relational database management system (DBMS), quick to implement and that can handle a large amount of data. It is not an ideal software package for all types of applications due to some important disadvantages in comparison to other databases (e.g. it does not directly support transactions and commit/rollback procedures; cannot handle complex sub-queries; and does not support triggers or stored procedures). However, it is adequate for the implementation of the simple logical model behind WePWEP.

A further aspect reinforced this choice: Keβler's prototype uses MySQL, so by adopting the same database server fewer modifications will be required to re-use his code. The version used for WePWEP implementation is 4.1.12.

VI.4.4. Geographical database server

Just as with alphanumeric data, it is advantageous to store geographical data in an integrated environment. ArcSDE is an application server by ESRI that facilitates storing and managing spatial data in a DBMS and makes the data available to many applications, including ArcIMS and ArcGIS Server - the selected spatial data publishers for WePWEP.

ArcSDE is not a database, but a piece of software (middleware) that sits on top of a relational DBMS and spatially enables it, so it becomes a geodatabase. In practice, it pushes the management of geographic data (i.e. storing and retrieval of data) to the client software seamlessly, while the relational DBMS is still responsible for keeping track of the tables and records contained in the database.

ArcSDE can be used with four commercial databases only: IBM DB2, Informix, Microsoft SQL Server and Oracle. Therefore, it could not be used with MySQL. UCL's Geomatic Engineering Department had available the Oracle Database Server 10g Enterprise Edition (release 10.1.0.3.0). As the advantages enabled by ArcSDE in spatial data storage and manipulation were significant (due to the great number of datasets involved and the large size of some, as for instance, OS MasterMap® data[43]), the Oracle database was adopted to store spatial data.

At this time the problem of keeping two databases, MySQL for alphanumeric (non-spatial) data and Oracle for geographic (spatial) data, was addressed, and, the option to store all data in Oracle was considered. Technically, this option would be recommended. However, since it would imply modifications in Keβler's prototype code and, less importantly, increase the dependence of WePWEP on the Internet (note that MySQL application exists in the main WePWEP server application), it was decided not to take forward this option. The fact that WePWEP is a proof-of-concept application also played a role in this decision. Were WePWEP aimed at commercial purposes, the alternative option would have been implemented.

The ArcSDE version used was 9.1, compatible with the ArcIMS and ArcGIS Server versions.

VI.4.5. Web programming language

JavaServer Pages (JSP) technology was adopted to generate dynamic web content on the server-side. JSP is part of the Java technology family, released by Sun Microsystems, and thus is platform independent. Moreover, it is relatively easy to learn and has good database support for popular relational DBMS, including MySQL. Another significant attribute is that JSP separates the user interface from content generation, enabling the designer to change the overall page layout without altering the underlying dynamic content. Despite these advantages, the choice for JSP technology was not free. Firstly, ArcGIS Server's web ADF can only be used in Java or

[43] Storing OS MasterMap® data in a database largely simplified its manipulation, in particular to create thematic layers (*cf.* section V.4.1.1, sub-section Applying the list of constraints: a GIS-based procedure/ Data preparation).

.NET environments. Secondly, Keβler's prototype is Java-based. Hence, JSP (Java technology) was the common denominator across all applications software.

The Integrated Development Environment (IDE) selected for WePWEP development was the open-source Eclipse's Java IDE, called Java Development Tools (JDT), which is part of the Eclipse SDK. The version of Eclipse JDT used was 3.1.0.

To facilitate the application development, two free of charge plug-ins were added to the original Eclipse SDK: a JSP Editor and the Tomcat plug-in. The latter simplifies the manipulation of Servlets and the Servlet engine (see next section).

VI.4.6. Servlet container

A Servlet container (also called Servlet engine) is the component of a web server that hosts and interacts with Servlets. Servlets are Java programs that provide additional functionality to the server or process data on the server. They are analogous to Java Applets that run within a web browser environment.

WePWEP requires a Servlet container for multiple reasons: firstly, because JSP are compiled into Java Servlets; secondly, because ArcIMS is a product that works in a Java environment, hence, demands a Servlet container to run; thirdly because building applications with the ArcGIS Server' Java ADF, which will necessarily be Servlet- or JSP-based web applications, requires a Servlet engine; and, finally, because Keβler's prototype makes use of numerous Servlets. Apache Tomcat (version 5.0) was the Servlet container adopted because it is free, popular, and compatible with both ESRI's software and Keβler's prototype. Moreover, because Apache Tomcat is "the servlet container that is used in the official Reference Implementation for the Java Servlet and JavaServer Pages technologies", according to the statement on The Apache Software Foundation website at the date of decision (The Apache Software Foundation, 2007).

VI.4.7. Client-side programming

A webpage (HTML) is basically static: the browser displays the text and graphics and waits for the user to read or fill in a form. Any dynamic behaviour is limited to clicking a link or submitting a form to a server and receiving more HTML. Client side programming adds dynamic behaviour to the client by executing a program on the web browser. Typically client-side programming is used for verifying whether data has been correctly entered or extending the capability of the browser. In WePWEP both functionalities are pertinent.

There are three types of tools for client-side programming: scripting languages (e.g. JavaScript), Plug-in (e.g. Flash) and Java Applet. JavaScript is popular amongst web developers and is well-supported by the most common web browsers (although it requires the JavaScript option on the browser to be turned on[44]). In addition, JavaScript, conversely to VBScript, are safe (i.e. cannot access client files and hardware) and do not require the installation of any software component. For these reasons, JavaScript have been extensively used in WePWEP for various purposes, including check the validity of entered data on the client-side before data are sent to the server and to display tooltips and informative labels when the mouse cursor hovers over a link or button.

Java Applets are also used in WePWEP. For example, Keβler's prototype embedded in WePWEP's third tier is an Applet. An Applet is a Java application that is inserted into a webpage. Since Applets made available the full functionality of the Java programming language, they permit greater interactivity than that possible using JavaScript.

Java Applets are downloaded automatically by the web browser when the webpage that includes them (by a special HTML Object of Applet tag) is received, and are executed as soon as the download is complete. The only prerequisite is that the browser must have a Java plug-in (Java VM) installed to run the Applet, which is free of charge. Like JavaScript, Java Applets are safe: they run in a Sandbox, which imposes strict limitations on what system resources the Applet can request or access. For example, an Applet cannot access any file on the client computer nor establish network connections to web servers other than the one it was downloaded from.

An important aspect when using Applets is the webpage loading time. Since the entire application, including data, must be transferred to the client, and it always takes a few seconds until the browser has launched the Java plug-in, loading a webpage with an Applet embedded takes longer than loading a thin client HTML webpage. Depending on the quantity of data transferred and the type of Internet connection, a significant amount of time can elapse until the webpage is properly displayed.

VI.5. Implementation of the alphanumerical database

Figure V.41 shows WePWEP's logical model. This model directly translates into the system's logical database design if each entity (box) is seen as a table, which will store the attributes of the entity, and each relationship is understood as an association between tables.

Prior to implementation, the logical database design needs to be converted into a physical database design. This consists of creating a design for storing data that provides adequate

[44] w3schools.com statistics on browsers reveal that over 90% of the browsers have JavaScript option turned on (http://www.w3schools.com/browsers/browsers_stats.asp).

performance and ensures database integrity and security. Details on how to carry out this task can be found in dedicated literature (e.g. Hoffer *et al.*, 2002; Connolly and Begg, 2004).

Figure VI.15 shows WePWEP's physical database model ready for implementation. The attributes associated with each entity and relationship and respective data types are displayed. During implementation, attributes become fields (columns) of the table and instances of the entities become records (rows of the table). Attributes in bold correspond to the table's identifier field. This serves as an index of the table, important to optimise data retrieval during search and queries.

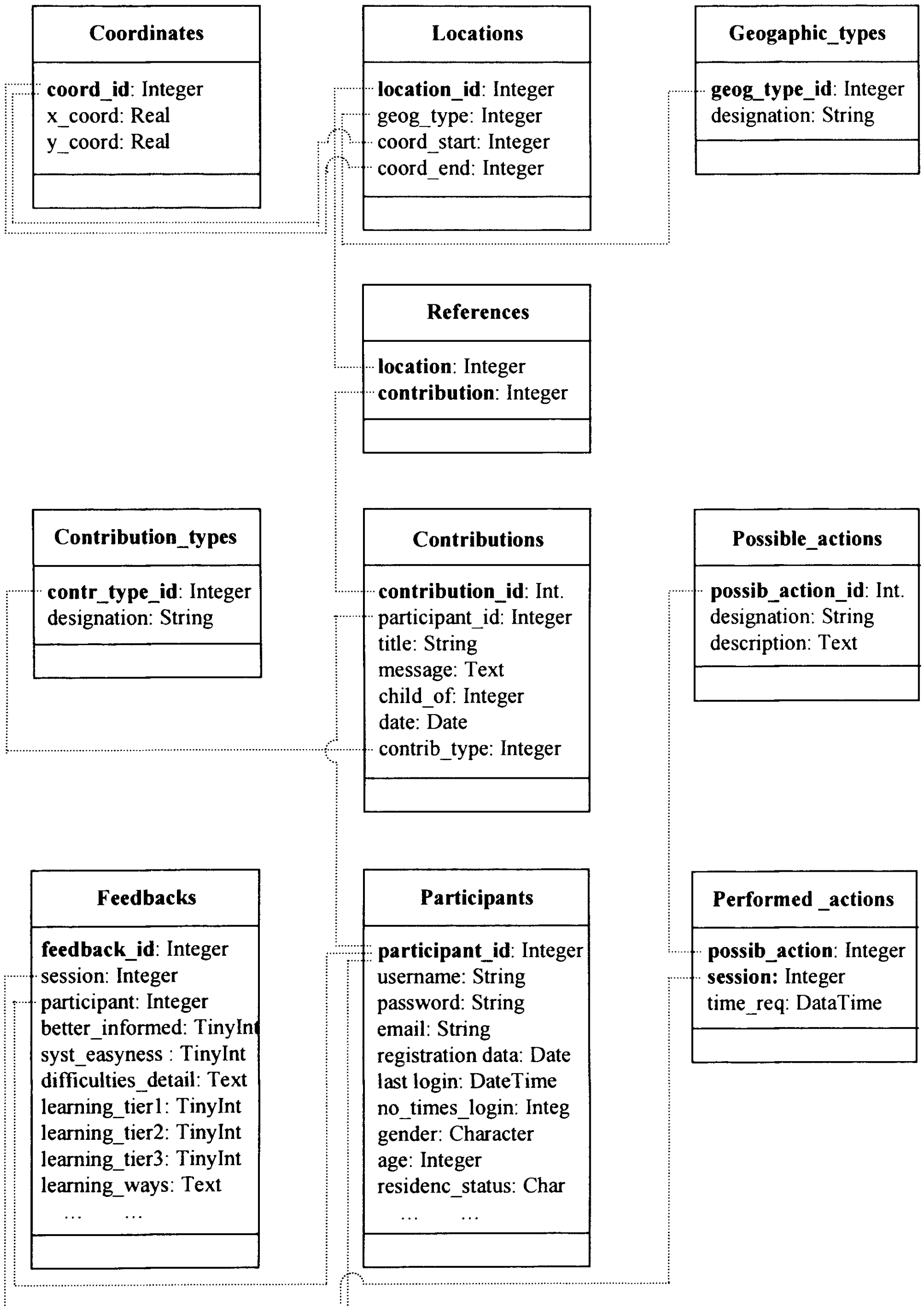


Figure VI.15 - WePWEP physical database design (continue).

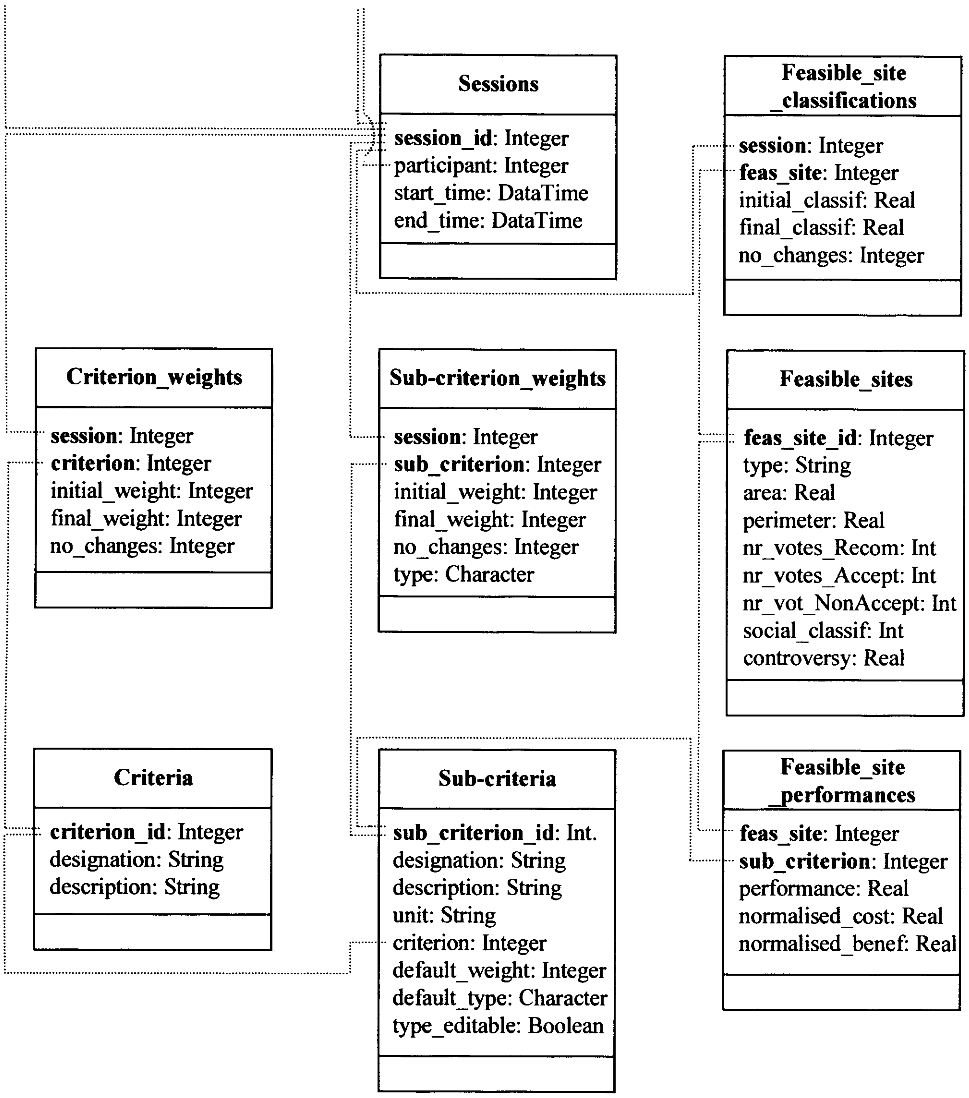


Figure VI.15 – WePWEP physical database design (continued).

Compared with the logical database design (Figure V.41), the physical database design includes five more tables. This is because the implementation of many-to-many relationships (i.e. relationships with cardinality superior to zero in both ends (e.g. '0..*'; '1..*'; '0..5', etc.) requires an auxiliary table. These tables have two identifier fields, which combined yield an unambiguous identifier (i.e. primary key) to each record (e.g. tables 'References' and 'Criterion_weights'). In addition, the 'Profiles' table disappeared. The reason is that, for implementation, it was found preferable to create a default user in the 'Participants' table to associate with all non-registered users (*cf.* section V.7.3) rather than keeping the two tables and the connection between them. In this respect, it is worth noting that the table 'Feedback' has a reference to the 'session', in addition to a reference to the 'participant'. This enables it to know exactly which non-registered participant has given feedback on the system.

The attributes of entities make two aspects clear:

- in one session, a participant can only assign one weight to each criterion, each sub-criterion and submit only one classification (otherwise the index field of the respective tables would not be unique); however, multiple weights and classifications can be experimented. Within the same session, new input replaces older one; for posterior analysis, it was decided to store the first submitted set of weights and classification and the number of changes (*cf.* tables 'criterion_weights', 'sub-criterion_weights' and 'feasible_site_classification', Figure VI.15); and
- any submitted input is associated with a participant (sometimes via the session that s/he works on); therefore, for returning participants, it is possible to retrieve and display previously submitted contributions (for instance, to enable editing) after their identification. Edited data or new input is stored associated with the current session, without modifying previous records. This enables the creation of a history of the participant's usage of the system and input data. Each time the participant re-visits WePWEP, all sessions of theirs are queried and the most recently entered data displayed.

The physical database design was implemented in MySQL (*cf.* section VI.4.3).

VI.6. Implementation of the first tier: information area

WePWEP's first tier was implemented in light of the requirements discussed in chapter III and the architectural design presented in chapter V. The greater workload in implementing this tier consisted of collecting information (specifically on local wind farm projects) and producing the text.

Technically, the tier is quite simple. Figure VI.16 shows the subset of WePWEP's architectural elements from Figure VI.14 involved in its implementation.

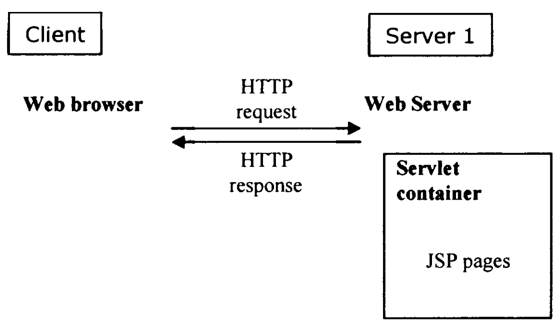


Figure VI.16 – Subset of WePWEP's architecture involved in the first tier.

On the server side, various JSP webpages are responsible for displaying static content (i.e. text, graphics and images). On the client-side, JavaScript programming was used to provide some degree of interactivity. For example, to create image rollover effects such as shown in Figure VI.17: green cones depicting locations of wind farms projects in Norfolk county become red when the mouse cursor is placed over; in addition, the designation of the selected wind farm is shown both as a label and on the top of the image, after 'Wind farm designation: '.

Figure VI.17 also shows the menu implemented to enable flexible navigation within the information area. The link "Return to main menu" on the menu brings the participant back to the portal entrance page, i.e. the main page of the first tier, where access to other tiers can be gained. At the bottom the page, not visible in Figure VI.17, "Previous" and "Next" buttons are also available to enable sequential navigation between pages (*cf.* section V.7.2). More screenshots of this tier can be seen in section VI.2, when a guided tour of the system is done.

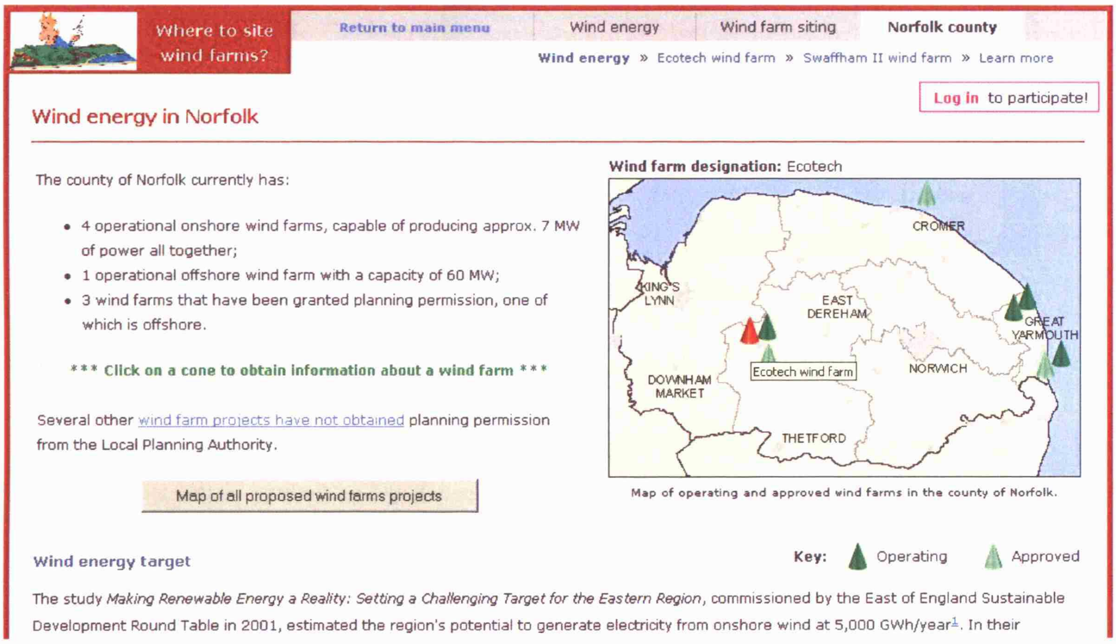


Figure VI.17 – Screenshot of part of a page from the WePWEP's first tier (partial screenshot).

VI.7. Implementation of the second tier: SDSS

Unlike the first tier, the second tier is rather complex. Figure VI.18 shows the subset of components of the WePWEP's overall architecture involved in this tier.

On the client-side, a few Java Applets provide some functionality. On the server-side, the functioning of the tier dependents on (1) JSP webpages to display static information and collect the participant input; (2) the ArcGIS Server software to edit and publish spatial information; and (3) on Servlets to process information entered by the participant, namely to store it in the alphanumeric database. Published spatial information is retrieved from the geographic database and a specific shapefiles folder. A shapefile is a digital vector storage format for storing geometric location (non-topological geometry) and associated attribute information (ESRI, 1998). The following sections describe the most relevant aspects of this tier's implementation.

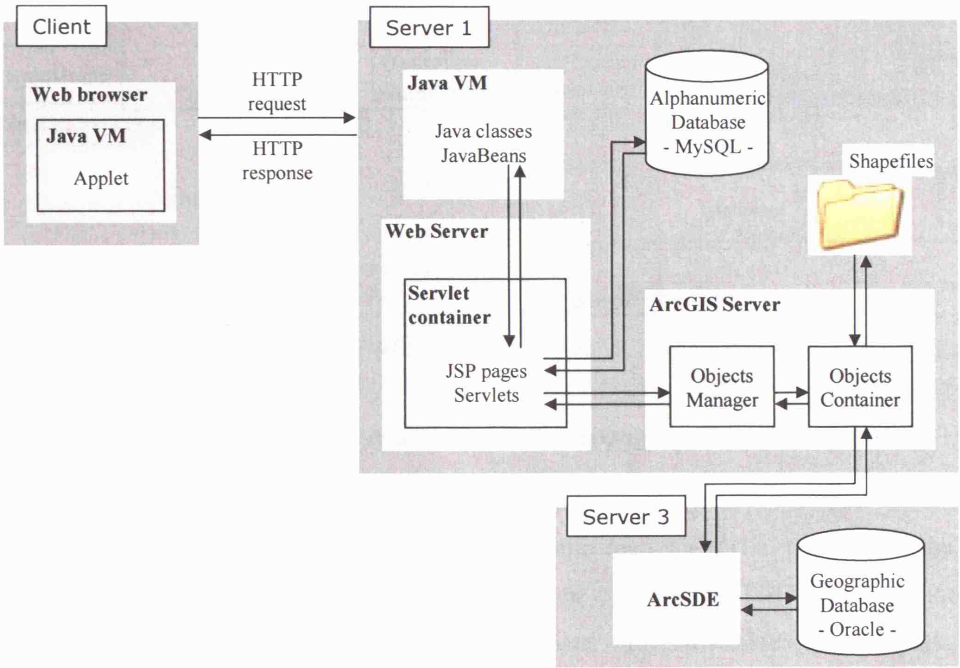


Figure VI.18 - Subset of WePWEP's architecture involved in the second tier.

VI.7.1. Development of the user interface

As specified in section III.3.2.2, textual and spatial information on one topic should be presented together, as well as input forms to collect the participant's views on it. Figure VI.19 shows the layout adopted for the WePWEP's second tier pages. It was optimised for 1024 x 768 pixels screen resolution, since it is the most popular (W3Schools, 2007)[45]. Dashed areas require scrolling down to become visible.

The *TopZone* across the webpage displays the logo, the title of the website and the navigation menu (*cf.* Figure VI.19b). The logo works as a link to WePWEP's home page. The *TextZone* identifies the topic addressed in the webpage, presents the essential information on the topic and provides links to webpages with more detailed explanations. Below, the *InputZone* hosts the input form to acquire the participant's contribution to decision-making. To the right are the *MapZone*, the *ToolsZone*, the *TOCZone*, the *OverviewMapZone* and the *LoginZone*. The latter enables the participant to log in and out; all other zones include ArcGIS Server's objects.

[45] Ideally, WePWEP should be resolution-independent (*cf.* section III.3.5). However, since ArcGIS Server objects require specific dimensions such ideal was unachievable.

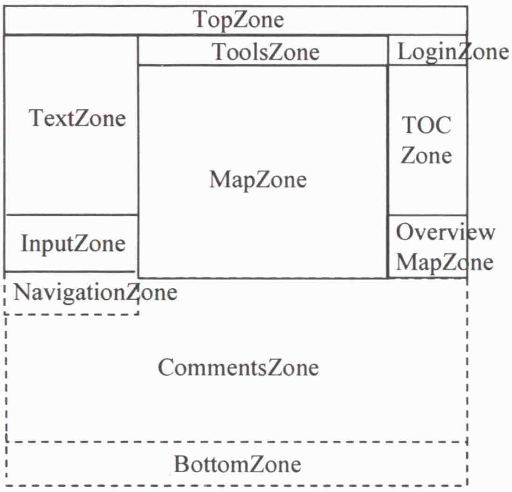


Figure VI.19a: Zones layout of WePWEP's second tier.

Figure VI.19b: An WePWEP's second tier webpage.

Figure VI.19 - Typical layout of a second tier's webpage including a map viewer.

MapZone is the largest area and hosts the map viewer. *ToolsZone* makes available the tools for map navigation and exploration and displays a dynamic map scale (i.e. the unit of the scale changes depending on the current map extent). *TOCZone* contains the TOC that simultaneously serves as map legend. It enables the participant to show/hide map layers. The *OverviewMapZone* includes a map of the whole case study area, and by means of a rectangle drawn on top of this map, it indicates at any time the exact extent and location of the area displayed in the *MapZone*.

At the bottom of the page, *NavigationZone* contains the "Next" and "Previous" navigation buttons. The *CommentsZone* includes a form for the participant to convey their appreciation on the current criterion (topic) and how it has been tackled for decision-making on the spatial problem at hand. Finally, the logos of the intuitions that supported the WePWEP development (i.e. this research project) are in the *BottomZone*, along with details of the system developer. Both the *TopZone* and the *BottomZone* are constant throughout WePWEP.

It can be noted that the layout adopted for webpages of this second tier looks quite similar to that adopted for pages of the first tier. Organisation-wise, components of the user interface are displayed in a consistent way (*cf.* Figure VI.17); this satisfies the requirement for system unity (*cf.* section III.3.4).

VI.7.2. Development of the MC-SDSS web application

The ArcGIS Server's Java ADF was used to develop the MC-SDSS application that constitutes WePWEP's second tier (*cf.* sections VI.4.2 and VI.4.5). The Java ADF is built on top of the JavaServer Faces (JSF) technology, which, according to its creator, is a Java-based web application framework that simplifies building user interfaces for JavaServer applications (Sun, 2007). In the Java ADF, JSF are used to create classes that support a set of web controls, such as map, TOC, north arrow, toolbar, etc..., and to provide access to the ArcGIS Server and, subsequently, to ArcObjects. The web controls are exposed as JSP tags, therefore, the MC-SDSS application consists of multiple JSP webpages, each embedding a few JSP tags.

The starting point for the application development was the creation of a simple web application using the Map Viewer template included in the Java ADF. The procedure followed is described in ESRI (2004), pages 237-240. The result was a JSP webpage containing a main map, an overview map, a legend/TOC, a north arrow, a scale bar and a toolbar with built-in tools for panning and zooming.

This JSP webpage was subsequently customised to the layout shown in Figure VI.19. Layout zones were implemented using HTML tables, included in an outer table that realises the body of the webpage.

Figure V.37 (section V.4.5) depicts the structural design of the second tier, with each box corresponding to a webpage. Twelve of these webpages include maps (*cf.* Table VI.1 ahead). These were created using the customised JSP webpage as template. Forty-eight other webpages were created to complete the WePWEP's second tier. These are essentially informative, providing details on the MCDM process underlying the tier and on the problem structuring (information presented in sections V.4.1, V.4.2 and V.4.3).

VI.7.3. Creation of Server object

WePWEP makes use of several ArcGIS Server objects of the type MapServer. These are responsible for displaying a map document in the user interface's *MapZone*. All MapServer objects used in WePWEP were pre-configured and pre-started in the server, so they were ready to use by the client application.

Configuration involves specification of the MapServer resource (i.e. the map document that will be displayed) and a few other parameters. A fundamental parameter is the server object's *pooling* configuration. Server objects can be *pooled* or *non-pooled*. Non-pooled server objects are created new for each application use and destroyed when released by the application to the server. Pooled server objects can be shared between multiple application sessions at the per request level (ESRI, 2004). Non-pooled and pooled server objects support different types of server applications. Pooled server objects are recommended for stateless mapping applications, i.e. applications that do not make changes to the server object or, in other words, after using the server object, it is released in the same state (with the same set of layers, the same rendered for each layer and so on). Non-pooled server objects should be used by stateful applications. Since the server object is destroyed when it is returned to the server, the application is free to change any aspect of the server object's state.

Table VI.1 lists the twelve JSP webpages (designations from Figure V.37) that include a map and the designation of the MapServer object that is loaded in the corresponding MapZone.

No.	JSP webpages	MapServer objects
1	Feasible sites	Feasible_Sites
2	Criterion 1	Visual_Impact
3	Weighting sub-criteria (1)	Sub_criteria_Visual_Impact
4	Criterion 2	Local_Impact
5	Weighting sub-criteria (2)	Sub_criteria_Local_Impact
6	Criterion 3	Impact_Ecology
7	Weighting sub-criteria (3)	Sub_criteria_Impact_Ecology
8	Criterion 4	Impact_Landscape
9	Weighting sub-criteria (4)	Sub-criteria_Impact_Landscape
10	Criterion 5	Site_ Characteristics
11	Weighting sub-criteria (5)	Sub_criteria_Site_Characteristics
12	Classification	Classification_Feasible_Sites No_Classification_Feasible_Sites

Table VI.1 – MapServer object to load in the corresponding JSP webpage's MapZone.

An additional MapServer object, called 'Overview_Study_Area', was created to load in the OverviewMapZone of these webpages.

Some of the MapServer objects were, in fact, created in two versions: a pooled and a non-pooled. Non-pooled versions are used in replacement of the corresponding pooled version under certain conditions. For 'Weighting sub-criteria (*i*)'-type webpages, the non-pooled version of the corresponding MapServer object is only loaded if the participant is logged in. The reason behind is that logged in participants can change the default weights (and types) of the sub-criteria involved in the computation of performances on the criterion (*cf.* section V.7.3) and, in case a default weight/type is changed, the map layer 'Overall performances on the specific criterion' (*cf.* Table VI.3) needs to be updated to reflect the change. This requires a non-pooled server object as alterations need to be made in the original resource of the corresponding MapServer object.

For 'Criterion *i*'-type webpages, the condition to load the non-pooled version of the corresponding MapServer object is if any default weight/type of the associated sub-criteria has been changed. As explained, this requires updating the 'Overall performances on the specific criterion' map layer of the currently displayed MapServer object, which, in turn, requires a non-pooled version of the server object.

For each MapServer object, Table VI.2 specifies the thematic layers included in the associated resource. Criteria and sub-criteria MapServer objects (see Table V.1) are grouped respectively under the designations '..._Impact_...' and 'Sub_criteria_...' because the respective resources include similar thematic layers. Table VI.2 makes clear the significant amount of spatial information involved in WePWEP, justifying the use of a geographic database (*cf.* section VI.4.4).

Thematic layers	MapServer objects					
	Overview_Study_Area	Feasible_Sites	..._Impact_...	Sub_criteria_...	Classification_Feasible_Sites	No_Classification_Feasible_Sites
Full area used for VIA[1]	x	x	x	x	x	x
Limits of the case study area	x	x	x	x	x	x
Location of large settlements	x	x	x	x	x	x
Administrative limits of counties within the area	x	x	x	x	x	x
Norfolk's districts administrative boundaries	x	x	x	x	x	x
Feasible sites disaggregated by possible wind farm typology (single and small)		x				x
Location of fictitious wind turbines			x	x	x	
Nature conservation designated sites (disaggregated by designation)		x				
Landscape and heritage designated sites (disaggregated by designation)		x				
Main rivers		x	x	x	x	x
Major roads disaggregated by type (A, B and minor)		x			x	x
Railway		x			x	x
Overall performances on the specific criterion			x	x		
A thematic layer for each sub-criterion involved in the computation of performances on the criterion				x		
Classification of feasible sites					x	
Raster map 1:10 000		x	x	x	x	x
Raster map 1:25 000		x	x	x	x	x
Raster map 1:50 000		x	x	x	x	x

[1] Study area plus a fringe of 20 km width around (*cf.* sub-section "Step three" in section 4.1.3.1, chapter V).

Table VI.2 – Thematic layers included in the resource associated with each MapServer object.

It should be noted that not all thematic layers are displayed at the same time: some are not visible when the map is loaded (the participant has the possibility to turn them on later); others have their visibility controlled by the displayed map extent (scale). For instance, the raster map 1:50,000 is only visible for map scales between 1:150,000 and 1:25,000. When the scale is greater than 1:150,000, the 'Full area used for VIA' is shown instead. When the scale is smaller than 1:25,000, the raster map 1:25,000 is displayed instead.

VI.7.4. Implemented functionalities

Following on from the use cases devised for the WePWEP's second tier (section III.2.2) and the way the tier has been developed (section V.4), the following functionalities, from the user point of view, were implemented:

- comment on aspects of the problem structuring;
- select the most important evaluation criterion for decision-making;
- weight evaluation criteria;
- change the default weight (and type, if possible) of sub-criteria involved in the performances' computation on evaluation criteria;
- generate a classification of the feasible sites; and
- revise stated preferences (i.e. criteria weights) and update the current classification of feasible sites.

The following sections provide relevant details regarding the implementation of these functionalities.

VI.7.4.1. Comment on aspects of the problem structuring

WePWEP welcomes comments on the way the problem has been structured (*cf.* section III.2.2). Figure VI.20 shows the user interface's component created to collect views on a specific aspect. The associated question was not designed so much with the purpose to acquire responses specifically on the aspect questioned, but rather to encourage WePWEP's users to think critically on how the problem has been prepared for them and to voice aspects that they feel are not tackled or under-considered. An unstructured input form has been selected to enable freedom in composing the contribution.

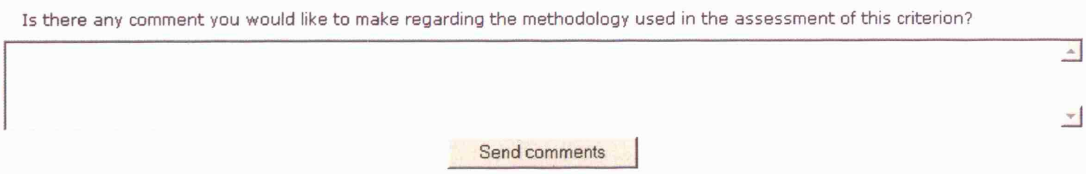


Figure VI.20 – User interface component to collect comments on the problem structuring.

This user interface component occupies the *CommentsZone* of the twelve webpages that follow the layout presented in Figure VI.19, and it is available to both logged in and non-logged in participants. Pressing the 'Send comments' button starts a procedure in the server (Servlet) that stores submitted input in the alphanumeric database and reloads the page, so the user can complete their work in that page.

VI.7.4.2. Select the most important criterion

Selecting the most important criterion is a functionality available in the 'Feasible Sites' webpage. The interface component for that is shown in Figure VI.21.

Figure VI.21 – User interface component for selecting the most important criterion.

On the client-side, the basis for its implementation is radio buttons and hypertext links (as noted in the interface component, the name of each criterion is a link which the user can follow to learn more about it). On the server-side, when the participant requests a new page, a procedure (Servlet) is triggered to store the input in the alphanumeric database. More specifically, the "Criterion_weights" table is updated with a new record that sets the weight of the most important criterion to 100.

Since the criteria weighting procedure depends on the most important criterion selected (*cf.* section V.4.2), a JavaScript routine was written to detect (and alert the participant of) changes in this selection. If a change is detected, a different procedure to that described above is triggered when the participant requests a new webpage. This procedure adds five new records to the table "Criterion_weights", one setting the weight of the newly selected most important criterion to 100, the others setting the weight of the remaining criteria to 0. This is because changing the reference criterion implies revising all weights entered thus far.

The interface component shown in Figure VI.21 occupies the *InputZone* of the pages that follow the layout presented in Figure VI.19 (*cf.* Figure VI.5), and, as it implies an active form of participation (i.e. the participant is expressing views), it is only available for logged in participants. Non-logged in participants will see instead the list of evaluation criteria for the decision problem and a message encouraging them to login.

VI.7.4.3. Weight a criterion

Weighting a criterion is a functionality available in all 'Criterion *i*' webpages, apart from the one corresponding to the most important criterion. Figure VI.22 shows the user interface component enabling this functionality.

Figure VI.22 – Use Interface component for entering the criterion's weight.

The horizontal scroll bar varies between 0 and 100 and is synchronised with the text box in front. The participant can either type a value in the text box or slide. If the participant types in a value higher than 100 or smaller than 0 an alert message is issued. This interface component was programmed in Java and consists of an Applet that is embedded in the webpages.

The participant's input is submitted when the participant requests a new webpage from the server. This process actually involves several steps. First, just before the request is sent to the server, a JavaScript routine is launched (on the client-side, still) to get the weight entered by the participant from the Applet; second, the value obtained is attached to the request to be sent to the server; and third, the request is, finally, forwarded to destination. On the server, a procedure is initiated to (1) check whether the new submitted weight is different from a previously submitted weight for the same criterion; and (2) if this is the case, or no weight for this criterion has been previously entered, the table 'Criterion_weights' is updated with the submitted value.

This interface component is displayed on the *InputZone* of the pages that follow the layout presented in Figure VI.19, but only for participants who are logged in and have set the most important criterion. Logged in participants who have not set the most important criterion yet will be informed of the fact, and offered a button that will drive them straight to the 'Feasible Sites' webpage, where they can initiate the weighting process. A non-logged in participant will see a message encouraging them to login, to contribute to decision-making.

VI.7.4.4. Change sub-criteria default weight and type

Performances on criteria are calculated by combining performances on the associated sub-criteria. To streamline the decision-making process, sub-criteria were given default weights and types, which the participants can edit (*cf.* section V.4.2 and Figures VI.6 and VI.7). Figure VI.10 shows the user interface component that enables this editing.

The interface is available in all 'Weighting sub criteria' webpages (*InputZone*), for participants who are logged in. It consists of an Applet, dynamically generated based on parameters passed to it through the webpage. The parameters are, in turn, dynamically collected from the database during webpage rendering.

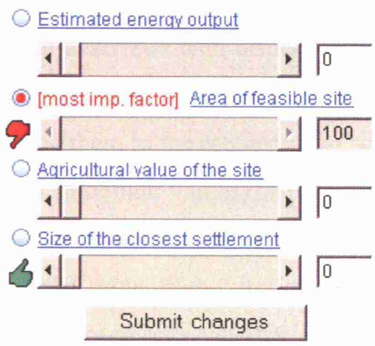


Figure VI.23 – User interface component for changing default weights and types of sub-criteria (associated with the 'site characteristics' criterion).

A radio button and scroll bar, identical to that used to weight criteria, is associated with each sub-criterion regarding the criterion being tackled. Consistent with user interface components already described, radio buttons are used to set the most important sub-criterion and scroll bars (and associated text boxes) to set weights. Furthermore, the sub-criteria' designations are links to informative pages on them, which open in a new, smaller window. Visited links change colour as they would in any JSP webpage.

The sub-criteria weighting mechanism follows the philosophy for criteria weighting: the most important sub-criterion is given weight 100 and the others are weighted in reference to it (*cf.* section V.4.2). When the Applet first loads, scroll bars and associated text boxes show the default weights. The user is then free to perform any change.

If a new most important criterion is set, the procedure launched mimics that described in section VI.7.4.2: the newly set most important criterion is given weight 100, while the weight of the remaining is set to 0. Figure VI.10 shows the result of this procedure after changing the default most important criterion 'Estimated energy output' to 'Area of feasible site'. Since all previous weights are erased when a new most important is set, each time that a new radio button is selected, a message is issued asking confirmation before the change of the most important criterion is realised.

The red and green signs (thumbs up and down) in Figure VI.10 indicate the sub-criteria for which the type can be changed. Sub-criteria with no thumb associated have a fixed type. Green thumbs up mark sub-criterion of type benefit (the higher the value on it, the better the performance). Red thumbs down mark sub-criterion of type cost (the higher the value on it, the worse the performance). To change the type of a sub-criterion the participant has only to click with the mouse on top of the current thumb. This is explained to the participant in the webpage, right above the Applet. Any changes require confirmation from the participant.

All changes are submitted to the server at once, by pressing the 'Submit changes' button. The procedure initiated is similar to that described with respect to submitting a criterion weight: just prior to submission, a JavaScript procedure runs on the client-side to get the weight and type values from the Applet and to attach them to the request to be sent to the server. On the server, a procedure checks whether changes to default values, or previous submitted input, have, indeed, been submitted and, if so, another procedure is initiated. The latter stores the new values in the alphanumeric database, updating the table 'Sub-criterion_weights' and reloads the webpage. During reloading, another procedure re-checks whether changes on sub-criteria weights/types have been made and, this being the case, the 'Overall performances on the specific criterion' map layer of the non-pooled MapServer object's resource is generated again based on the newly submitted data.

This latter procedure involves:

1) querying the alphanumeric database for the right data;
2) standardising the sub-criteria weights;
3) computing performances on the criterion taking into account performances on the sub-criteria and corresponding standardised weights; and, finally,
4) updating the attribute table of the 'Overall performances on the specific criterion' with the results of the computation.

This last step requires the use of ArcObjects[46], which are accessed via the MapServer web control class. It is at this level that the Java ADF, part of ArcGIS Server software package, makes a difference. Were ArcIMS chosen to implement this tier, accessing ArcObjects would involve significantly more programming.

VI.7.4.5. Generate a classification of feasible sites

Based on default (or submitted) sub-criteria and criteria weights, a classification of feasible sites needs to be generated and presented in the 'Classification' webpage. There is no user interface component to generate the classification. It is generated automatically by a procedure that runs when the 'Classification' webpage is requested from the server, if the participant who requested it is logged in and has set the most important criterion.

The procedure consists of various stages, including:

1) standardisation of the criteria' weights;

[46] To simplify access to spatial data manipulated via ArcGIS Server, such files (shapefiles) are left in Server 1 (Shapefiles directory) instead of being stored with similar type of information in the geodatabase, Server 3.

2) computation of performances of every alternative on each evaluation criterion, attending to the alternatives' performances on the sub-criteria and the respective weights for decision-making, which also need to be standardised;

3) combination of results from the previous steps according to the selected decision rule (*cf.* section V.4.3);

4) storage of the new results on the table 'Feasible_site_classifications' in the alphanumeric database and update of table 'Feasible sites', fields associated with the computation of the "social" classification of feasible sites and associated controversy;

5) update of the attribute table of the map layer 'Classification of the feasible sites', published by the 'Classification_Feasible_Sites' MapServer object, with results from step 4; and, finally,

6) setting of the correct rendering of this map layer, knowing that feasible sites must be assigned to classes based on the thresholds introduced in Table V.23.

When this procedure is finished, the 'Classification' webpage terminates the loading and will exhibit the new classification. Steps (4) and (5) involve manipulation of ArcObjects.

VI.7.4.6. Revision of stated preferences

After analysing the generated classification of feasible sites based on submitted input (which may be combined with default weights and types for sub-criteria), the participant may like to revise stated preferences. Figure VI.11 shows the user interface component that supports this functionality. This component appears in the *InputZone* of the 'Classification' webpage, when it is requested by a participant who is logged in and with the most important criterion selected.

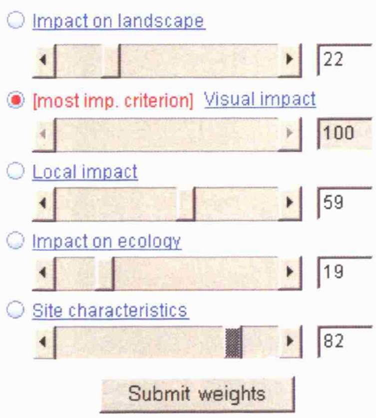


Figure VI.24 – User interface component for revising criteria weights and update a generated classification of feasible sites.

The "look and feel" is very similar to that described in previous sections, namely section VI.7.4.4 regarding the change of weight and type of sub-criteria. Hitting the button 'Submit weights' also precipitates a similar set of actions to the button 'Submit changes' then described: it updates the alphanumeric database with the participant's new input and reloads the webpage. A difference occurs during the loading of 'Classification' webpage because the procedure described in the previous section is triggered instead. When the page finishes the loading, the newly generated classification of feasible sites will be displayed.

VI.8. Implementation of the third tier: AM

Keβler's prototype was selected to realise the AM offered by WePWEP (*cf.* section V.5.1). Thus, the implementation of WePWEP's third tier involved the following steps:

1) setting up the selected prototype;
2) learn its code;
3) integrate the prototype into the design set for the tier (*cf.* section V.5.4); and
4) perform the necessary changes to fulfil the requirements of the third tier.

Figure VI.25 shows the subset of components from the WePWEP overall architecture involved in this tier.

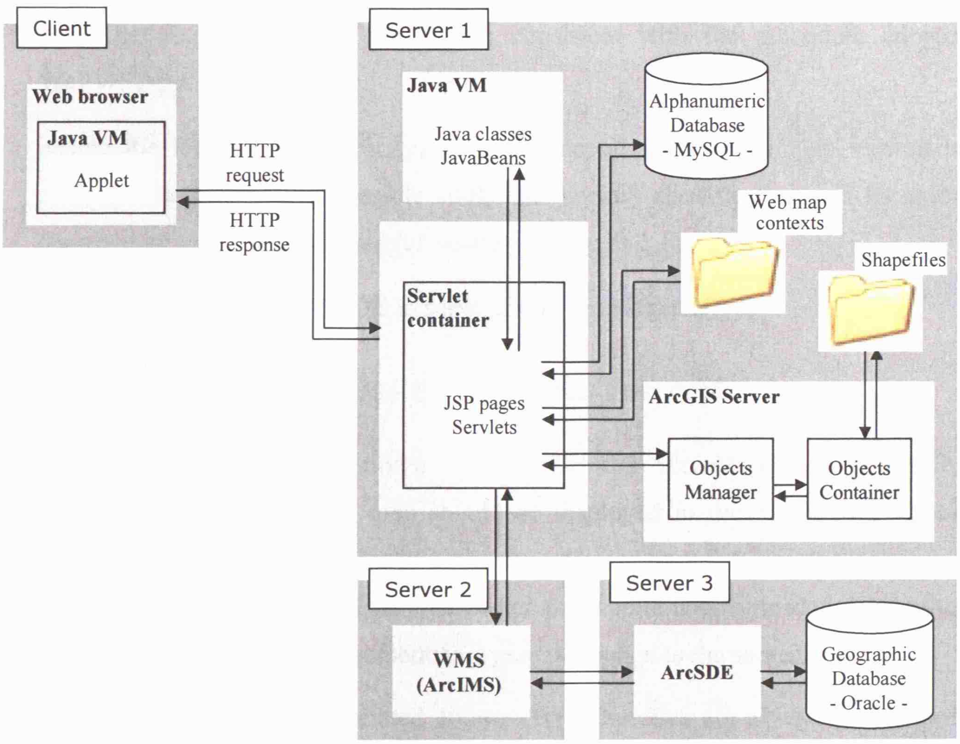


Figure VI.25 - Subset of WePWEP's architecture involved in the third tier.

On the client-side, AM functionality is provided via an Applet. On the server-side, (1) a WMS (ArcIMS) is used to publish backdrop spatial data in the map viewer collected from both the geographic database and the shapefiles folder, respectively, via ArcSDE and ArcGIS Server; (2) the alphanumeric database stores and serves all submitted textual contributions as well as the geometry of the contributions' spatial references; (3) the ArcGIS Server creates and updates shapefiles during runtime, which are saved in a specific directory; and (4) another directory is used to save web map contexts (WMC). These are XML-based files that store the visible map layers and map extent at the moment that a contribution is submitted. They can be later loaded by any participant into the AM, enabling him/her to visualise the spatial context that the author of that contribution had in view when s/he submitted it (Keβler *et al.*, 2005). The following sections describe the most relevant aspects of this tier's implementation.

VI.8.1. Adaptations to the original prototype

A number of modifications were made in the original AM's code, the most relevant being the following:

- let the Applet receive as a parameter the ID of the session that the participant is currently working on (*cf.* section VI.10.1 ahead) and attach this reference to any request sent to the server (URL-rewriting); this permits the participant to continue working on the same session;
- make the registration/login mechanism consistent with the procedure adopted for WePWEP (*cf.* section V.7.3);
- enable the loading of several map layers (shapefiles) into the map viewer, so the personal classification of feasible sites, the "social" classification and its associated controversy map can be viewed (*cf.* section V.5.2); and
- improve the map viewer's TOC to serve also as map legend.

VI.8.2. Update of shapefiles to load into the AM

The participant's generated classification of feasible sites, the "social" classification of feasible sites and its associated controversy map should be displayed in the AM's map viewer (*cf.* section V.5.2). A user-transparent procedure was programmed to update/create these shapefiles, so they are ready to be transferred to the client when the Applet is downloaded. This procedure is triggered by the request of the 'Argumentative map' webpage to the server.

The "social" classification and associated controversy shapefiles are always passed onto the client, irrespective of the login status of the participant (*cf.* section V.7.3). These shapefiles exist by default on the server (within the shapefile directory); however, their update is necessary before they are transferred to the client because new personal classifications might have been created, or existing ones revised, since the last time they have been updated (i.e. the last time the 'Argumentative map' webpage was requested). The update of these shapefiles is performed based on data retrieved from the table 'Feasible_sites' from the alphanumeric database (*cf.* Figure VI.15). As mentioned in section VI.7.4.5, this table is updated each time a new classification is generated.

The personal classification shapefile is only passed onto the client if the participant is logged in and has created a classification, either in the current session or in a previous one. By default, personal classification shapefiles do not exist on the server, even if the participant has created one in the current section. In fact, as explained in section V.7.4.5 above, when a new classification of feasible sites is generated, the edited shapefile is the 'Classification_Feasible_Sites', part of the map resource being published by the 'Classification_Feasible_Sites' MapServer object (*cf.* Tables VI.1 and VI.2). (If the analysis of the WePWEP usage reveals that the majority of participants that create a classification of feasible sites in the second tier do, actually, proceed to the AM, the currently implemented procedure can be changed to create (and save in the system) a classification shapefile indexed to the creator and replace the existing 'Classification_Feasible_Sites' shapefile in the map resource published by the 'Classification_Feasible_Sites' MapServer object by the new one – instead of just editing the existing 'Classification_Feasible_Sites' shapefile.)

Therefore, a personal classification shapefile has to be created when needed. The necessity is evaluated by a routine that checks whether a personal classification shapefile for the current participant exists in the shapefiles folder. This check is based on the name of the shapefiles because all created personal classification shapefiles are saved as "Participant_*x*", where *x* is the unique participant identifier generated by the database when the participant first registers.

If a personal classification shapefile is found for the current participant, it is updated with data retrieved from the table 'Feasible_site_classification' in the alphanumeric database; update is required because the personal classification might have been edited after the shapefile has been created or last updated. If no personal classification shapefile is found for the current participant, one is created at runtime. This procedure consists of: (1) select an existing shapefile, a personal classification shapefile if any exists or the "social" classification shapefile otherwise; (2) copied it and renamed based on the identifier of the current participant (copying a shapefile is computationally more economic than creating one from scratch); and, finally, (3) edit it with information associated with the current participant retrieved from the table 'Feasible_site_classification'. This procedure makes use of ArcObjects, available through ArcGIS Server, and a slightly different way to get hold of these objects had to be implemented because no web controls (exposed by JSP tag) are available in the 'Argumentative map' webpage to provide access to them.

Since all created personal classification shapefiles are stored in the system, to avoid storing a large number of shapefiles, some of which might not be needed again, each time the procedure for updating the "social" classification and associated controversy shapefiles runs, it deletes all "Participant_*x*" shapefiles older than *y* days old (*y* was set equal to 5).

Finally, to account for the case when the participant logs into WePWEP from the 'Argumentative map' webpage, a routine was included in the login procedure to check whether the participant has ever created a classification of feasible sites. If so, the corresponding shapefile is updated/created and loaded into the AM's map viewer.

VI.8.3. Integrating the second and third tiers

To simplify and stimulate iterative learning, as well as to fulfil the requirement for wholeness, connections should be set up between the different tiers of WePWEP (*cf.* section III.3.4). One connection found particularly relevant is that between the 'Argumentative map' webpage (Figure VI.9), where participants can enlarge their perspectives from reading other participants' contributions and analysing the "social planning solution", and the 'Classification' webpage (Figure VI.8), where participants can revise their personal proposal for the problem resolution.

This connection was implemented via a button named "Revise sites classification" placed just below the navigation menu in the 'Argumentative map' webpage. This button is available only for participants who have created a personal classification (so revision makes sense). On the destination webpage ('Classification'), a button was created to enable direct return back to the departing webpage ('Argumentative map').

When activated by a participant that has not yet developed a personal classification of feasible sites, this button displays a message referring the participant to the "Feasible sites" webpage, where s/he can initiate this process.

VI.9. Implementation of the fourth tier and registration/ login procedures

The fourth tier corresponds to the feedback questionnaire. From the technical point of view, it involves similar functionalities to the registration/login process; hence they are both tackled together in this section. Figure VI.13 shows the subset of WePWEP full architecture involved in these implementations.

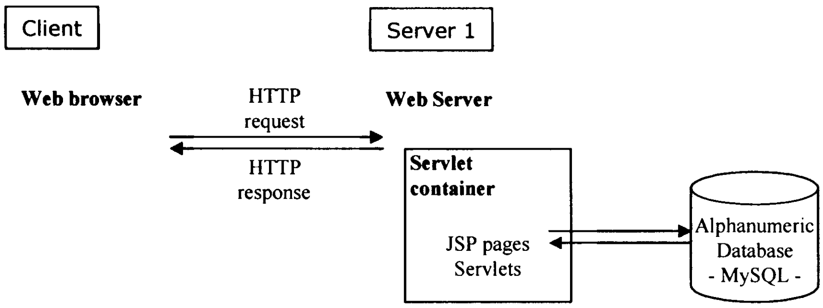


Figure VI.26 - Subset of WePWEP's architecture involved in the fourth tier and registration/login process.

Thin client HTML webpages (as the JSP webpages are rendered), with forms embedded in them, request and receive participants' input. On the server-side, Servlets save supplied data in the alphanumeric database. To minimise flows over the Internet during the registration and login procedures (which always involve waiting time), JavaScript code was used to check data validity on the client before sending it to the server. When problems are encountered, alert messages are issued to help to the participant solve them (*cf.* section V.7.3), and no data is sent to the server. When data is sent to the server, another data validity check is run to account for the case where the JavaScript option is turned off on the client machine. If problems are encountered, help messages to resolve the problem(s) are sent back to the client, or the "problems solve" web page is displayed.

In the fourth tier, data validity checks were not implemented because feedback is not mandatory and structured input forms were used when a specific format response was sought.

VI.10. Implementation of other application components

In addition to implementation of the four tiers, other aspects had to be addressed to ensure the fulfilment of all requirements and make using WePWEP a pleasant experience. The most relevant of these aspects are:

- the session concept;
- features for returning participants; and
- collecting information on WePWEP's usage by the participants.

The following sections summarise how these aspects have been tackled.

VI.10.1. Session object

When using WePWEP, the participant goes through several webpages. During this route, data needs to be passed across. For example, the weight set for a criterion in a certain webpage will be needed to generate a classification of feasible sites at the end of the weighting process. Since data is stored in the database, required data could be retrieved from there. However, constant access to the database slows down the application. As an alternative, WePWEP uses a Session object to pass information around.

A new Session object (henceforth, session) is created by the WePWEP application server whenever it receives from a browser a request without reference to an existing session (typically when a new participant visits the system), and is destroyed when:

- the participant submits feedback on the system (fourth tier) – here, it is assumed that s/he has concluded her/his participation; or
- the session expires – sessions are set to expire if the participant does not request (or refreshes) a WePWEP webpage for a period of thirty minutes.

In sessions, data is stored in key-value pairs, with value being any object. A form to minimise the number of pairs being passed around in the session, is to write a JavaBean that encapsulates many objects and pass it around. A JavaBean is a Java class that obeys certain conventions, such as about the functions' (methods') names to get or set the value of a member variable. This technique is used in WePWEP. A JavaBean is created as soon as the session is created and immediately attached to it. In addition to storing data, the JavaBean also serves as pivot to initiate procedures. For example, the procedure that generates a classification of feasible sites is started from the JavaBean.

To avoid having the session expired while the participant is working on a webpage (e.g. reading) and all data being lost, a JavaScript routine was programmed to warn the participant when the session is due to expire within 5 minutes. Participants are advised to refresh their webpage to carry on their work. If no action is taken, the routine re-runs one minute before the session expires.

Since sessions rely on cookies, when a WePWEP webpage is first requested, a check for cookies support is performed on the requestor's browser. If it is found that cookies are not supported (the requestor might be using a old browser or have cookies disabled in their browser), the requestor (potential participant) is informed that without cookies s/he will not be able to enjoy the full functionality of WePWEP, and information on cookies and how to enable them in the browser is provided.

VI.10.2. Returning participants

Imagining a situation where a participant had to leave WePWEP and returns later on to complete their participation, or where a participant returns days after to check the evolution of the discussion forum and/or the "social planning solution", features were programmed to load from the database input submitted by the participant. This enables him/her to continue their work from the point where it was left, or edit previous input.

The retrieval of previous input from the database happens immediately after the participant logs in. For each parameter (e.g. weight of a criterion), the most recently submitted input is retrieved. These data are stored in the JavaBean, in structures that facilitate their access, and will be displayed in the correct webpages and used for logical processing.

VI.10.3. Tracking the participant

Section V.7.4 discusses the types of information that should be collected to "track" the usage of WePWEP by a participant: (1) visited webpages and their sequence; (2) time spent on them; and (3) actions executed on each.

From the implementation point of view, capturing data on the two first aspects does not pose special problems. This was implemented through a Servlet that, before sending the requested webpage to the client, registers in the database (table 'Performed_actions') the request and the current time. The request is selected from the table 'Possible_actions' (*cf.* Figure VI.15). Along all WePWEP webpages (as request a webpage is an action), this table records actions such as closing off a webpage that has been opened by clicking on a link.

In contrast, capturing data on the third aspect requires complex programming (for instance, to identify the zoomed area and the panned map extent). As any interaction with maps in the second tier (ArcGIS Server) implies reloading the page, these actions are indirectly logged by the latter Servlet (i.e. the requested map extent is not logged but it is logged that some type of map manipulation has occurred). In the third tier (Applet), capturing data on executed actions is even more difficult because it would imply constant traffic flow between the client and the server, which would slow down the "reaction" of the Applet. Data buffers would have to be used to store collected data, and be sent to the server at opportune times to be stored in the database.

Due to the complexity of implementing a procedure that captures map manipulation and other actions within a webpage, this has not been implemented. Instead, a work around was used: a screen recording software was used to capture (in video format) all interactions participant-WePWEP (*cf.* sections VII.2.4.3 and VII.4.3).

VI.11. Discussion of the achieved implementation

Overall, the achieved WePWEP implementation is able to provide a smooth experience to the user. However, there are several aspects that can be improved in future versions to make it lighter-weight and a more robust and computationally economic system.

Firstly, Applets in the client should be avoided: (1) because they require a Java-enabled browser, and having to install a Java plug-in may put off some potential participants in the planning process; and (2) because they require some downloading time, which depending on the Internet connection and on the amount (and type) of information transferred, can be quite significant (*cf.* section VI.4.7). Currently Applets are used in the second tier to receive input by the participant on the evaluation criteria and sub-criteria (*cf.* sections VI.7.4.3, VI.7.4.4 and VI.7.4.6); and in the third tier as the AM is itself an Applet. Regarding the first situation, JavaScript programming can be used to achieve similar functionality. Concerning the AM, other prototypes exist that offer similar functionality to Keβler's and do use Java technology, hence Applets. One of such systems is Tang's GeoDF, based on PHP technology (*cf.* section II.4.3). Adopting this system, however, would pose new technological challenges as PHP and Java technologies (the latter is required because of ArcGIS Server) would have to be made compatible, namely in terms of the session concept in which the participant works in. Indeed, for data to be passed around between tiers (e.g. from the second to the third tier), a connection between the Java and the PHP sessions would have to be implemented – which is possible.

Secondly, due to the different software basis used in the second and third tier, currently the "look and feel" of the map viewer and map navigation tools is not exactly the same in both tiers, although reasonably similar and based on the same principles. Some re-design work at this level could improve the look of WePWEP from this point of view.

Third, since the newer version of the ArcGIS Server (v. 9.2) is already an OGC-compatible WMS (*cf.* section VI.4.2), ArcIMS is no longer required as part of the third tier's architecture.

Finally, as mentioned in section VI.4.4, the alphanumeric database is not strictly required and all data, spatial and non-spatial, can be store in a geodatabase (Oracle in the current project). Moreover, shapefiles currently stored in a shapefile folder (*cf.* Figure VI.14) (to streamline its access) can be, with advantages (e.g. compactness), stored in the database; and the same goes for WMC files, currently also stored in a special directory.

If all this is implemented, a thin client, perfect three-tier architecture (*cf.* section VI.3) can be achieved for WePWEP, Figure VI.27. Being more integrated, this architecture is easily scalable and, therefore, it is more convenient for large real-world applications (or commercial use).

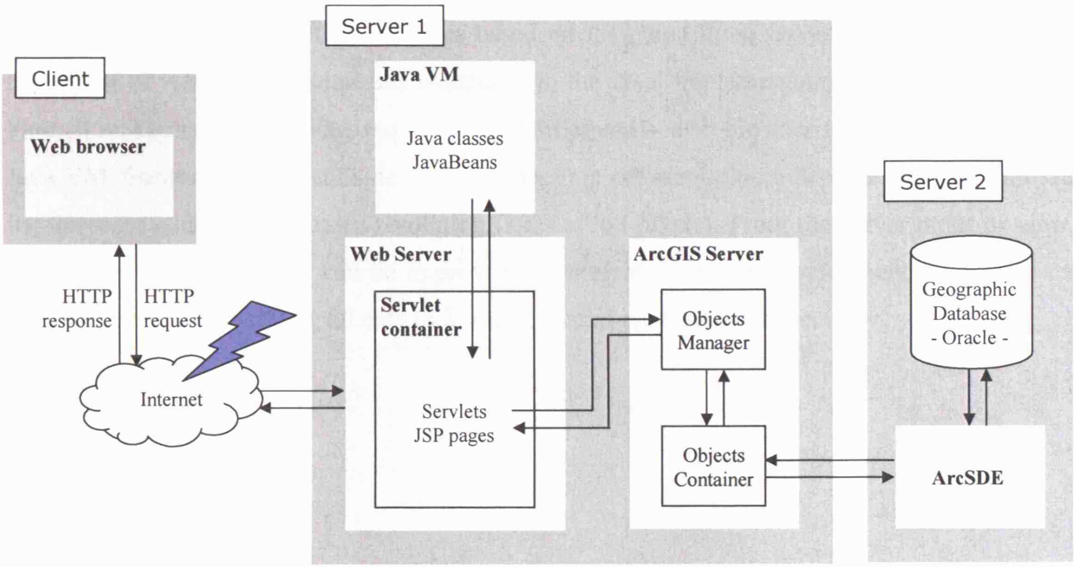


Figure VI.27 – Ideal (and achievable) architecture for WePWEP.

Regarding the application/use of the achieved implementation by (public) organisations, the following two comments should be made:

- during the development, attention was put in not to embed (hard-code) specific data/parameters in the application: all parameters are passed onto WePWEP from configuration files or are retrieved from the database (e.g. number of criteria and sub-criteria, respective designations, etc); this makes re-using the code for different applications/data much easier (naturally, webpages will need to be modified); and
- the number of software packages involved and the costly selling price of some, especially ArcGIS Server, may hinder a large-scale implementation/(re-)use of WePWEP; the technical skills required to set up the application may also play a role here.

VI.12. Conclusion

This chapter describes the WePWEP implementation. At the outset a guided tour of WePWEP is provided to introduce the system and then technical aspects of the implementation are presented and discussed, namely the system's architecture and options made with regard to technologies and software packages. Subsequently, the chapter reports on implementation work and finally critically review the achieved implementation. The chapter has not been written from a technical perspective, although some technical details are provided; this is to let the interested readers understand how the implementation has been accomplished.

Overall, WePWEP is a complex system. It involves various software, some of which involving recent technology (e.g. ArcGIS Server is based on JSF), and three server computers. From the user point of view, two weaknesses compared to the ideal implementation can be pointed out. First, it makes use of Applets, requiring the participant's web browser to be equipped with a Java VM. Secondly, the client-side (user interface) is not resolution independent, but optimised for the most widely used screen resolution (1024 x 768 pixels). From the server point of view, the current implementation can be improved by integrating newer developments and software packages and by assembling all data in a single, spatial-enabled database.

Chapter VII

Testing, loading and evaluating WePWEP

VII.1. Introduction

Following implementation, and in preparation for the WePWEP evaluation, the prototype was tested and loaded. Testing aimed to assess its functionality and identify aspects that could be polished and improved to increase the level of acceptance by its users and provide them a more enjoyable experience. Loading aimed at populating the "social" classification of feasible sites and the AM with views from key stakeholders in the wind farm siting process. The idea behind it was to make WePWEP more interesting and thought-triggering for next participants. The actions undertaken and results achieved in these two stages are reported in this chapter. Subsequently, the experiment conducted to evaluate WePWEP is described; the results are presented in the next chapter. This chapter finishes with a brief summary of the most relevant aspects discussed throughout.

VII.2. Testing and improving WePWEP

VII.2.1. Procedure overview

WePWEP testing followed the conventional testing procedure, associated to different releases of the software: alpha version; beta version, release candidate (i.e. the version with potential to be the final product), and gold version or the general availability release. The WePWEP version right after implementation was called alpha. During the alpha test this version was actively debugged by the developer (i.e. the author); the aim was to ensure that the product worked. An improved version of the system, beta version, was submitted to the beta test. This test had a similar purpose to the previous one but the protagonists were a sample of potential users of the system. Improvements on WePWEP led to the release of a candidate version. This version was also tested: the pilot test. In contrast to previous ones, the pilot test had for main objective the simulation and test of the experiment designed to "formally" evaluate WePWEP. Figure VII.1 outlines the WePWEP testing procedure.

Alpha test

- Date: 3 and 4 April 2006
- Aim: ensure the correctness of WePWEP's response to users' actions and that all information is being correctly acquired and stored in the database
- Who: PhD candidate while system developer

Beta test

- Date: 13 April 2006
- Aim: test and evaluate the prototype design and its capability to cope with simultaneous users
- Who: 3 doctoral candidates
- Duration: approx. 1.5 hour/session

Pilot test

- Date: 10 and 12 May 2006
- Aim: test and evaluate the experiment design to assessment WePWEP and also collect suggestions to improve both the prototype and the experiment design
- Who: 2 MSc students, 1 doctoral candidate and 1 PhD graduate
- Duration: approx. 1.0 hour/session

Figure VII.1 – Structure and details of WePWEP testing procedure.

VII.2.2. The alpha test

During the alpha test the following aspects were inspected:

- WePWEP response to all possible interactions;
- links, both internal and outwards, to make sure they were active;
- all outward links should open up in a new, smaller pop-up window, leaving WePWEP's webpage waiting in background;
- whether submitted input was being correctly stored in the (alphanumeric) database;
- whether the data collected by the "user tracking" mechanism would enable the reconstruction of their route (and some actions) within WePWEP;
- whether WePWEP ran correctly in the major web browsers (since Internet Explorer, version 6, was used for development, the system was optimised for that browser);
- whether WePWEP displayed properly at different browser resolutions (the system was tuned for the 1024 x 768 pixels display resolution, *cf.* section VI.7.1).

Naturally, this test led to several corrections. At the end of this process, WePWEP ran correctly in the browsers Internet Explorer version 5, 6 and 7 and Opera version 7 and 8. However, problems appearing when the Mozilla Firefox browser[47] was used could not be resolved, despite out best efforts.

Regarding the resolution, some WePWEP webpages were modified to make their display more harmonious in higher resolutions (1280 x 1024 and 1600 x 1200 pixels) – for example the size of the AM's Applet (and respective webpage) was changed to automatically adjust to the client's browser resolution.

VII.2.3. The beta test

The beta test was carried out in the Centre for Advanced Spatial Analysis (CASA) and involved three participants. Their recruitment was by invitation, and no special attributes were sought apart from interest in the work being conducted and availability to participate.

VII.2.3.1. The participants

The three participants were doctoral candidates and frequent users of the Internet. None of them were particularly knowledgeable about wind energy or wind farm siting issues, so they accepted the opportunity with a view to learning about the subject. Two of them had experience in designing websites and were GIS literate; the third participant was completely unfamiliar with these areas.

[47] The warning "Additional plug-ins are required to display all media on this page." appears in the place of the Applet.

Although it can be argued that the recruited participants are not truly representative of the WePWEP intended audience since they are researchers, the sample is diverse with respect to GIS literacy (and map interpretation) and they share with the likely users of WePWEP an interest to learn about wind energy and wind farm planning issues. Moreover, the fact that two participants were familiar with website design was seen as an advantage as they could judge and contribute to enhancing the WePWEP usability.

VII.2.3.2. Running the test

Each participant was given a computer with a 1024 x 768 pixels screen display and asked to use WePWEP freely. The three participants used the system simultaneously as one of the objectives for this test was to assess WePWEP's ability to cope with concurrent usage. The author played the role of observer/facilitator while the participants used the system. Participants were questioned about any difficulties they experienced and whether the purpose of the system and what they could do within it was clear. The participants' seats had been arranged in a way that this sort of interaction with one participant would not disturb the others.

Since no time-period was set for the test, the participants concluded their session at different times. As they finished, an informal discussion was held with each participant individually to learn more about their opinion of the system and about aspects that they deemed to need improvement having in mind the ultimate goal of the system: enhancing learning. This discussion replaced the filling in of the feedback questionnaire in the WePWEP's final tier.

VII.2.3.3. Test outcome

Participants adopted different approaches in using the system. The non-GIS researcher spent longer in the information area (first tier), whereas the two GIS literate researchers were more interested in experimenting and exploring the system's functionalities. Their sessions span for different periods. The longest and the shortest sessions were by the GIS-persons, respectively with the duration of 1 hour and 12 minutes and 42 minutes.

All participants registered with WePWEP and created a personal classification of feasible sites (in WePWEP's second tier) but only a GIS-person (the one that took longer using the system) contributed to the discussion taking place within the AM (in WePWEP's third tier), despite all visiting this webpage.

The system coped perfectly with the three simultaneous users and their usage was correctly tracked by the implemented mechanism. Additionally, WePWEP responded well to the participants' challenges, including those by a participant (the one who used the system the longest) who, adopting a "bad participant" behaviour, tried to submit an incomplete profile, entered incorrect data (e.g. a UK postcode that did not comply with the correct format), requested a new password, etc.

At the end of the session, all participants stated that they enjoyed using WePWEP. The following comments were also made:

- navigation within the system was easy and well designed;
- the system has too much text: it should be shortened to retain one's attention;
- maps take some time to load and they re-load each time they are manipulated; and
- the AM is not intuitive to use: people not familiar with GIS will have difficulties to explore the map layers (e.g. understanding the layers overlapping) and tooltips seem insufficient to guide the users through the procedure of (creating and) associating a spatial reference to their written contribution.

VII.2.3.4. Enhancement of WePWEP

Based on received comments and recommendations, two main enhancements of WePWEP were performed:

- text in the informative webpages was shortened and their content "sharpened" by focusing on the main points; and
- a group of webpages was created to assist participants using the AM; these are accessible through a button added to the user interface named 'How to use this webpage?' and are organised in tabs as the AM itself. When pressed, this button opens up a new, smaller browser window that floats over the WePWEP main webpage, displaying information about the AM's map tools and enabling access to other domains where assistance is provided: using the discussion forum, understanding and manipulating map layers and using the search and analysis tools, Figure VII.2.

Regarding the maps loading/re-loading comment (*cf.* previous section), there is no way around it. The re-load of the webpage (and map) after any action on the map is a characteristic of ArcGIS Server; therefore, it cannot be changed without a lot of programming. Concerning the time required to load the map (and complete the rendering of the webpage), tests conducted showed a minimal dependence between the information being transferred and shown on the map and the webpage loading time.

Figure VII.2 – Set of webpages created to assist participants using the AM (partial screenshot).

VII.2.4. The pilot test

In contrast with the previous tests, the pilot test did not aim exclusively at testing and improving WePWEP, but also at testing and improving the quasi-naturalistic experiment designed to evaluate the success of the proposed conceptual framework based on the implemented prototype.

It is opportune to note that the quasi- naturalistic experiment tested and subsequently conducted does not coincide with that originally planned to assess WePWEP. The experiment initially conceived consisted of a real-world experiment: the system would be released online simultaneously with an "advertising campaign" and for two weeks the system would be up and running, free for members of the public to use. During this period, two "*x*-day" events (one in each district crossed by the study area) would be run at the local library or other public facility, so people without Internet connection or computer/Internet experience could use WePWEP with assistance.

However, the lack of a suitable context to promote WePWEP (such as a wind farm development being discussed at the time) and the limited resources available to carry out such an experiment led to opt for a quasi-naturalistic experiment. This was planned with "public" recruited from a particular environment: the University of East Anglia (UEA) (*cf.* section VII.4.1below).

VII.2.4.1. Test design

The pilot test was designed to assess the quasi-naturalistic experiment planned for the UEA. Below is a list of controlled parameters:

- each session will have a maximum of two participants, so observation on how they use the system and assistance, if needed, will be possible;
- participants' interaction with WePWEP will be recorded using a video camera (because the tracking mechanism implemented in WePWEP does not capture all user-system interactions – *cf.* section VI.10.3);
- participants will be asked to use WePWEP freely for approximately 1 hour;
- participants will be encouraged to look for assistance in the system prior to addressing questions to the observer/facilitator, to simulate "real-world" conditions; and
- participants will be asked to fill in the feedback questionnaire at the end of the session.

VII.2.4.2. The participants

Four participants took part in the pilot test: two UCL's MSc students in GIS with a strong interest in wind energy and wind farm siting, and a PhD student and a PhD graduate, both with connections to CASA. The two latter's main motivation to participate in the session was learning about WePWEP itself, rather than wind farm siting issues. All participants were recruited by invitation.

Table VII.1 summarises some characteristics of the participants according to information supplied by them during registration in WePWEP. Furthermore, all participants stated to (1) feel very comfortable using computers; (2) use the Internet daily; and (3) be used to interpreting maps.

Participant	Age group	Knowledge of		Visited a wind farm in the past 5 years?
		Wind energy	Case study area*	
1	25-29	well informed	5	No
2	30-34	well informed	2	Yes
3	25-39	know a little	1	No
4	25-29	know a little	1	No

* answers on a 1 to 6 scale where 1 is do not know and 6 is know well

Table VII.1 – Basic characteristics of participants in the pilot test.

VII.2.4.3. Running the test

The test took place at UCL's Department of Geography. Laptops with a screen resolution of 1024 x 768 were used and digital video cameras set up to record the participant's interaction with WePWEP. Difficulties in setting up the video camera to capture the screen from an acceptable angle without becoming too intrusive led to the realisation that this was not the best device to fulfil the purpose: software that records all desktop activity can be used for the same end and is much less intrusive.

Two sessions, of two participants each, were initially scheduled. However, one participant missed their session, so a third session was scheduled for May 12th 2006. This created an opportunity to test screen recorder software as a replacement for the video camera. The selected software was ScreenCorder (MatchWare, 2006), which records all the operation on the computer screen down to movements of the mouse cursor and mouse clicks.

VII.2.4.4. Test outcome

Table VII.2 sums up the participants' opinions about WePWEP in the pilot test. It also contains a reference to their session duration.

Participant	Session duration	Better informed after using WePWEP?[1]	Is WePWEP easy to use?	How well WePWEP achieves its goal?[2]	Time to complete the website?[3]
1	1:08:28	5	Mostly	5	4
2	1:34:31	6	Yes	6	2
3	0:32:50	3	Partly	6	4
4	1:16:23	5	Mostly	4	3

[1] answers on a 1 to 6 scale with 1 = learnt nothing and 6 = learnt a lot

[2] answers on a 1 to 6 scale with 1 = fails the goal and 6 = achieves entirely

[3] answers on a 1 to 6 scale with 1 = very little and 6 = too much

Table VII.2 – Broad appreciation of WePWEP by participants in the pilot test.

The majority of participants found WePWEP relatively easy to use and stated that it achieves its purpose: enhancing learning on the spatial problem at hand. Two participants perceived the time required to complete the website as a little too long (4 on a 1 to 6 scale) but, interestingly, the participant who spent longer in the system (1 hour and 34 minutes) did not have a similar perception (marked 2 on the same scale).

With regard to difficulties experienced, participant 2 noted that the map legend in the second tier was difficult to read and participant 4 wrote that none of the 5 types of contributions possible ('pro', 'contra', 'neutral', 'suggestion' and 'question') seemed adequate to start a discussion thread. His point was that the first two types would only be adequate to support or refute an existing comment and the following three would not be suitable to mark a statement such as "Wind turbines look nice" or "Wind turbines are noisy".

As for future WePWEP improvement, participant 2 suggested the inclusion of

> "... some 3D viewshed visualisation to show users how many turbines they can see from a selected point." (Participant 2)

Finally, observing that an existing wind turbine is located outside an area identified as feasible for wind farm siting, participant 4 added a noteworthy contribution to the discussion forum:

> "I find it interesting to note that the existing wind farms are in locations that have not been classified as a 'feasible site'. Does this mean that this system will not contain

> many sites that are feasible? Or should these farms not have been built in the first place?"

Noting that this comment could alarm future participants who might not understand why this had occurred, the discussion moderator, i.e. the author, replied to this contribution as follows:

> "In short, yes. The reverse can also happen, i.e. sites identified here as feasible for wind farm siting can actually be found unfeasible for this purpose. The identification of (a) feasible site(s) is a very complex procedure: it requires detailed information (e.g. wind data), many analyses and visits to the site and its surroundings. This justifies why, in the real world, wind farm sites are proposed by developers.
>
> The procedure we conducted to identify feasible sites mimics that carried out by wind farm developers when searching possible wind farm sites. However, no site visits were carried out and we did not consider specific reasons for installing wind turbines at particular sites. (…)
>
> [Information on the aspects that need to be considered when searching for wind farm feasible sites can be found at (…)]"

Fundamentally, the moderator explained that selecting a wind farm site requires the consideration of many aspects, not exclusively technical, and it is a decision made on a case-by-case basis as local features play a important role for the final decision.

VII.2.4.5. Enhancement of WePWEP

Based on the pilot test outcome, some improvements were carried out in WePWEP. Firstly, the legend of all "overall impact" map layers was changed from "normalised performances" to "site suitability classes" to make the layer interpretation more intuitive, Figure VII.3.

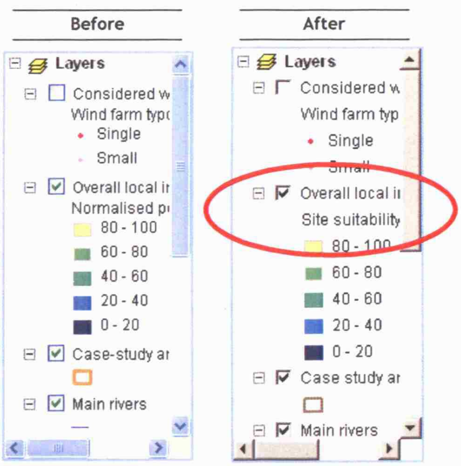


Figure VII.3 – Impact map legend before and after the changes.

In addition, the tooltip "The darker a feasible site, the less suitable it is for accommodating a wind farm" was added to the map viewer. This reinforces the message written beside the map:

> "The map on the right shows the overall *visual* impact for each feasible site: darker sites are less suitable for wind farms[1]." (*visual* is replaced in each case by the correct type of impact)

Footnote 1 explains the relation between the suitability classes and the normalised performances, a concept introduced in an WePWEP's auxiliary webpage.

> [1] The higher the site suitability score, the more appropriate the site is to accommodate a wind farm. For each feasible site, the site suitability score is the normalised performance of the site on the criterion visual impact, calculated based on the identified factors.

Despite these improvements, map legends are still somewhat difficult to read due to the vertical and horizontal scrollbars. However, this is inevitable due to the screen display resolution constraining the webpage layout[48].

Secondly, concerning the type of contributions available, a solution was conceived that offers different user interfaces (panels) for 'starting a new thread' and 'reply to a contribution'. The former would have three contribution types available: 'statement', 'suggestion' and 'question'; and the latter would have the current five: 'pro', 'contra', 'neutral', 'suggestion' and 'question'. However, this improvement was not considered as crucial for testing the system, so it will be implemented in a future version of WePWEP.

VII.2.5. Appraisal of the testing stages

Improvements to WePWEP based on comments by participants during the testing stages proved the advantage of testing software prior to release. With respect to the planned experiment to assess WePWEP, the pilot test elucidated that:

- ScreenCorder software is a much less intrusive solution to record the interaction between the participant and WePWEP than a video camera;
- the time required by ScreenCorder to assemble and export into a video format the acquired data during a participant's session is quite significant[49] (for a session lasting 1 hour and 18 minutes over 2 hours were needed to produce the final video) – this raises the problem of the number of software licences available for the experiment as, while

[48] Alternative layout designs were experimented but results were considered inferior to the adopted one.

[49] The video is created from screenshots (frames) captured at regular time intervals – for the experiment the default setting was adopted: 8 frames per second.

converting data, the software licence is in use, hence cannot be used to record another session; and

- a one-hour session may not be enough for participants to go through the whole system since a significant amount of time can be spent reading background information.

With regard to the last point, and for the 'formal' WePWEP evaluation experiment, it was decided to send to recruited participants a PDF file containing all background information available in the system prior to their session. Behind this decision is the assumption that, having read the background information prior to the event, participants will spend more time construing and re-construing their contribution to the planning decision-making process.

VII.3. Loading WePWEP

WePWEP includes a discussion forum which is naturally of greater interest if populated with contributions. The same goes for the "social" classification of feasible sites. Loading WePWEP corresponds to the stage where key stakeholders in the planning process of wind farm siting were invited to give their contribution and, thus, populate both the discussion forum and the "social" classification.

This stage effectively happened at two different times. First, even before the testing stages, letters of representation included in the planning application process of operating wind farms were consulted and their argument transposed to the AM. Eleven discussion contributions were added to the forum, organised in seven discussion threads. The objective was to create a basis of work to encourage testers to add their own contribution but also to demonstrate the purpose and the functioning of the AM. As for the "social" classification, it was initiated with the author's personal classification of feasible sites.

The second phase occurred at this stage, when WePWEP was ready for the evaluating experiment at UEA. This point is important because, in addition to getting key stakeholders' views in wind farm siting to initiate the debate, two other aims were set for this phase:

- introduce WePWEP as a new planning tool capable of involving the general public in strategic planning; and
- gain feedback on WePWEP by people who already know about the problem at hand, hence, they should be more interested in exploring the functionalities provided by the system than reading background information – feedback from these people was considered valuable because it is assumed that most of their learning would come from exploring the decision problem within WePWEP's second tier and from visualising the "social planning solution" and written contributions attached.

The following sections provide details on this phase.

VII.3.1. Approaching stakeholders

An initial contact was made on April 28th 2006, with an email sent out to key contacts in ten organisations with interest in wind energy and wind farms planning, Table VII.3. The email introduced WePWEP and invited them for a meeting (to be arranged) where they could explore the system and enter their views on wind farm siting. To make the invitation more appealing, snapshots of WePWEP were attached to the email in a PDF file. Furthermore, in an attempt to enlarge the audience of the email, recipients were invited to forward it to people within their contact network with a potential interest in exploring WePWEP (application of the 'snowball technique' for recruitment).

	Organisation	Sector
1	Norfolk County Council	
2	King's Lynn and West Norfolk District Council	Local public bodies
3	Breckland District Council	
4	Campaign to Protect Rural England - Norfolk	
5	King's Lynn and West Norfolk Friends of Earth	Conservation and environmental organisations
6	Norwich Friends of Earth	
7	West Norfolk RSPB Local Group	
8	British Wind Energy Association	
9	Ecotricity	Wind energy industry
10	E-on UK	

Table VII.3 – List of stakeholders invited to "load" WePWEP.

Replies to the email expressed interest in the proposed meeting, suggested contacts of people potentially interested in using WePWEP, or justified their lack of interest in attending the proposed meeting. Stakeholders who did not reply to the email were approached by telephone a week later, but this turned out to be unfruitful. In total, six people and two institutions (the local District Councils) showed an interest in using WePWEP.

VII.3.2. Meeting with stakeholders: organisational details

Stakeholders interested in using WePWEP acceded to a visit to their Council, so two half-day events were organised at Breckland District Council and King's Lynn and West Norfolk Borough Council. Both Councils collaborated in the organisation of event, namely by offering a room with an Internet connection and advertising the event through their internal mailing list (i.e. amongst their colleagues). An additional meeting was held at CASA for a person who could not attend the Council event and was coming to London.

Meetings were planned with three parts: (1) an introduction to WePWEP supported by a prepared presentation; (2) a hands-on session for the participant(s); and (3) a debriefing session to collect opinions about the system.

VII.3.3. Running the meetings

The first meeting was held at CASA on May 11th 2006. As planned, it began with a presentation of WePWEP and moved on to the hands-on session. Short after, the participant started a conversation around the advantages and disadvantages of nuclear power *versus* wind energy, likely urged by the webpage 'Debate around wind energy' that he was reading at the time.

The conversation evolved as the participant continued exploring WePWEP and concentrated on the planning application processes of some wind farm proposals in whose Public Inquiry he had been involved. Two hours later, the participant had to leave, and the meeting ended without the participant having explored the more interactive parts of the system (second and third tiers).

The participant's global appreciation of WePWEP was very positive and he applauded, in particular, the webpages dedicated to Norfolk's wind energy projects (both existing and planned), which he considered a valuable resource for local citizens and institutions. Regarding the development of the meeting, looking back, it seems natural that conversation had arisen because wind energy is a rather controversial topic and the participant was right beside the person who had written the text he was reading and framed the problem in a certain way. In general, the participant questioned wind energy as an energy option for the country compared with, for instance, nuclear power. The participant seemed to be very much in favour of nuclear power.

Events at the Councils took place on May 23rd 2006, in the morning (9:30 am to noon) at Breckland Council and in the afternoon (2 to 5 pm) at King's Lynn and West Norfolk Council. In Breckland, six persons attended the meeting: three local citizens that had previously been involved in local wind farm campaigns and three planning officers. At 9:45 am all participants but one were in the room, so the "meeting" started according to plan: with a short introduction of WePWEP, projected onto a large screen available in the room. The hands-on session followed. As only two computers were available, participants organised themselves in groups, with one participant assuming the lead on the computer. Each time a new webpage was requested, conversation/discussion occurred amongst members of the group. When the sixth person arrived, he joined the smaller group and received, from his "colleagues", a brief of the system and what they had been doing. During the hands-on session, the author acted as observer/facilitator and also took part in the discussions. As the setting was not appropriated to formal debriefing interviews, notes on participants' comments and responses to questions about the system were taken during the hands-on session. All participants stayed until the end of the session, at noon, and had the opportunity to visit the four tiers of WePWEP (although only the groups' leader operated the system).

Comments received from the participants indicate that they enjoyed using the system and found it a very useful and opportune resource. In particular, they commented favourably on the way the wind farm siting problem is approached within WePWEP, on the comprehensiveness of the evaluation criteria set, and on the advantages emerging from a person having to formally rationalise their decision-making. With regard to the system's usability, no comments were recorded regarding particular difficulties on using WePWEP or about this being a difficult system to use overall. Maybe this is due to the fact that a computer/Internet-skilled participant naturally took the lead in operating the system. Participants did mention, however, that the links to access the webpages where it is possible to revise default weights and types of sub-criteria were not obvious.

The event at King's Lynn and West Norfolk Council was only attended by two people, both from the Council Planning Division. The plan for the meeting was followed, but the hands-on sessions were marked by technical problems. After a morning session without incident, the main map in some webpages of the second tier (ArcGIS Server objects) stopped loading, making impossible the creation of a personal classification of feasible sites. Despite best efforts, the problem could not be resolved on site and the event terminated with a more comprehensive presentation of WePWEP's functionalities. The next day the problem had been resolved and the web address of WePWEP was sent by email to both participants. Only one returned to the system: he created his own planning proposal for siting wind farms and added some contributions to the discussion forum. Moreover, he filled in the feedback questionnaire at the end. Table VII.4 provides an overview of their evaluation.

Participant	Session duration	Better informed after using WePWEP?[1]	Is WePWEP easy to use?	How well WePWEP achieves its goal?[2]	Time to complete the website?[3]
1	00:43:10	4	Mostly	5	6

[1] answers on a 1 to 6 scale with 1 = learnt nothing and 6 = learnt a lot

[2] answers on a 1 to 6 scale with 1 = fails the goal and 6 = achieves entirely

[3] answers on a 1 to 6 scale with 1 = very little and 6 = too much

Table VII.4 – Feedback on WePWEP by stakeholder in the wind farm siting process.

Additionally, the participant did not point out any difficulties and, as expected, he said that the second and third tiers were the ones that most contributed to his learning: on the 1 to 6 scale, being 6 'learnt a lot' and 1 'learnt nothing', he gave 5 to these two tiers and 4 to the first tier (information area). Worth noting is that he considered that completing the website took him too much time.

VII.3.4. Evaluation of the loading stage

The loading stage can be evaluated based on the extent that the announced goals were met. The fundamental goal cannot be said to have been fully achieved: only few contributions were entered into the system during the course of the "meetings". To improve this result, key contacts at both Councils were asked to distribute WePWEP's web address amongst their colleagues (via internal mailing list) and encourage them to use it. In addition, other individuals, mostly from academia and with an interest in wind energy/wind farm siting, were contacted with the same purpose. Two other people used WePWEP following this initiative.

In contrast, the two other aims set for this stage (*cf.* section VII.3) have been accomplished to a large extent. WePWEP was introduced to members of public organisations and a few individuals with an interest in wind farm siting and the feedback received was very encouraging: WePWEP's potential for engaging the public in strategic planning of wind farms was highlighted and it was acknowledged as a valuable and useful information system. Participants particularly enjoyed the information available on local wind energy projects.

From a personal point of view, it was rewarding to observe that WePWEP does indeed stimulate exchange of ideas around wind energy and wind farm siting, in particular, when a group of people are joined together around the system.

VII.4. The WePWEP evaluation experiment

Following the testing and loading of WePWEP, a formal experiment was carried out to assess to what extent the proposed public participation framework does indeed contribute to enhancing learning and promote the development of better informed contributions to spatial planning problems. As discussed in section VII.2.4, the public experiment that actually took place was different to that initially conceived. Instead of truly launching WePWEP for public use, an experiment was organised at UEA, located in Norwich, approximately 35 km from the eastern boundary of the study area.

The UEA was selected for three reasons. Firstly, amongst academic and managerial staff, students and researchers, a university is a "repository" of people from different backgrounds and skills, thus a diversified group of participants could be recruited to constitute the "public" of the experiment. Secondly, its relative proximity to the study area increased the likelihood of recruited participants knowing the study area, even if only by passing by. Thirdly, a well-equipped laboratory was available to run the experiment, which would significantly simplify the logistics of setting up and running it.

VII.4.1. Organisational elements

The experiment was scheduled for June 1st, 2nd and 5th 2006 (Thursday, Friday and Monday) at the Zuckerman Institute for Connective Environmental Research (ZICER)'s Laboratory, School of Environmental Sciences, UEA. The laboratory was equipped with fast desktop computers[50] with large monitors (19 inches and resolution 1280 x 1024, higher than that WePWEP was optimised for, 1024 x 768) and broadband Internet connection.

Twenty participants were found a sufficient number for the purpose of this research. Sessions of one hour duration were organised from 9:30 to 18:30, with 30 minute intervals to absorb any possible delays or allow the application server to be restarted, should any problem occur (as happened during the "loading" session at King's Lynn and West Norfolk Borough Council). Each session could have a maximum of two participants and the ScreenCorder software would be used to record participant-WePWEP interaction during the sessions (as during the pilot test).

A successful application for joint award from the UCL Graduate School and Department of Geography provided some money to reward participants for the time spent on the experiment.

VII.4.2. Recruitment methodology

To recruit participants, colourful posters were prepared to affix on boards throughout the UEA as well as an e-mail message to be sent through several of UEA's mailing lists. People interested in participating in the study (and get the £15 reward) were requested to get in touch as soon as possible as only 20 participants were sought and they would be allocated on a first come, first served basis.

On May 16th the advertisement process was set off with the e-mail message being sent to the School of Environmental Sciences's all-department (academic and non-academic staff and research postgraduates) and undergraduate/taught postgraduate students mailing lists – a group of over 700 individuals. Half an hour latter, more than 20 e-mails had been received from volunteers to participate in the experiment. Clearly, the combination of the wind energy topic, School of Environmental Sciences and the reward in offer was very effective. To be coherent with the advertised allocation procedure, affixed posters were retracted and no other mailing list was used to diffuse the message. Over the next days, more e-mails from volunteers were received, up to a total of sixty-eight.

Twenty volunteers were selected from the first forty e-mails received. The selection procedure tried to gather a "public" as diversified as possible regarding gender and the highest level of

[50] Pentium® 4 with 2.8GHz CPU and 1.0GB of RAM.

education. First names provided a clue on the volunteers' gender; and for the education level, the volunteers' introduction was considered (various identified themselves as under- or postgraduate student or staff); and also the signature included in some e-mail (some made a reference to 'PhD candidate' or a position at the University). Regarding the volunteers who only provided a name, a search by their name or/and e-mail address was made on Google, which often returned a reference enabling his/her identification as postgraduate student or faculty member. When no reference was found, the volunteer was assumed to be an undergraduate student.

Selected volunteers were contacted and queried about (five) preferential sessions to attend from the possible ones. To all the remaining volunteers a reply was sent informing them that, due to limited budget, they could not be paid for their participation in the experiment but they would be welcome if still interested in participating. Eight volunteers expressed their interest in taking part in the experiment without pay.

Volunteers were allocated to sessions depending on their preferences/availability and a last e-mail was sent indicating their session, the meeting time and place and including a PDF file with the background information on wind energy, wind farm siting and wind energy in Norfolk available in WePWEP (*cf.* section VII.2.5). The e-mail informed them that reading the information in the PDF file was not strictly necessary for the experiment, but it was recommended as they could spend more time exploring the more interactive parts of WePWEP during their session.

VII.4.3. Running the sessions

Each session was divided into three parts:

(i) Introduction

A 5-minute introduction served to recapitulate the purpose of the session (this information has been provided in e-mails sent) and highlight some aspects regarding the hands-on part, namely:

- participants are free on how to use the system;
- some parts of WePWEP are more interactive than others;
- participants' interaction with WePWEP was going to be recorded with a built-for-purpose software; this should be unnoticeable;
- during the session I will be around, looking at how participants are getting on and available to provide help if needed – i.e. play the role of observer/facilitator;

- however, participants are encouraged to look for assistance/information on the system before asking the observer/facilitator to simulate "real-world" usage of the system; and
- participants should fill in the feedback questionnaire included in WePWEP.

In addition, participants were given a slip of paper with the question "Have you read the document (PDF file) sent with background information?". The answer was requested on a 1 to 6 scale, 1 meaning "have not read" and 6 meaning "read it thoroughly".

(ii) Hands-on part

For the hands-on part, participants were sat next to each other, facing opposite or perpendicular direction. This layout was chosen to simplify the role of the session's observer/facilitator, which consisted in taking notes on aspects regarding the participants' interaction with WePWEP[51] and providing short explanations over a few pre-identified aspects. For example, the 'Weighting sub-criteria' webpages in the second tier, which, according to previous users of the system, can be easily missed (*cf.* section VII.4.2); and the handling of the maps and controlling of the map display, in particular in the AM where difficulties have been identified by earlier users (*cf.* section VII.2.3.3).

(iii) Debriefing

A short debriefing interview concluded each session. Participants were asked (1) whether they had enjoyed the system; (2) which part they had enjoyed more and why; (3) their views on the selected sequence for WePWEP: first, provide background information on the problem at hand; then a "laboratory" where they could create their own planning proposal; and, finally, a discussion forum about issues on the problem and proposed solutions, with the possibility to return back to the "laboratory" to revise their own planning proposal; and 4) their thoughts about using WePWEP in the "real-world" to involve the public in the strategic planning of wind farms.

Interviews were tape recorded and depending on the finishing time of the participants, they were conducted individually or in a sort of conversation involving both participants. The results of this experiment are presented in the next chapter.

[51] This was important because only two licences of the software ScreenCorder were available, so while images captured during one session were being post-processed and converted into video format, sessions could not be recorded (*cf.* section V.2.5).

VII.5. Summary

This chapter reports on testing and loading the implemented version of WePWEP. Testing was conducted in three stages: alpha, beta and pilot tests. The alpha test was carried out by the author and aimed at ensuring that WePWEP was fully functional and working well in the most common web browsers. The beta test was conducted by three volunteers and aimed at testing the acceptance of the system by intended audience and find out aspects for improvement. Finally, the pilot test was conducted by four people, and its goals were two-fold: (1) to collect suggestions to improve WePWEP; and (2) to test the design for an experiment to "formally" evaluate WePWEP with regard to the fundamental idea behind its conception, i.e. improving learning.

Loading WePWEP aimed at populating the AM and the "social planning solution". Stakeholders on wind farm siting (excluding the local/general public) were invited to use the system but, despite the efforts, the fundamental goal set for this stage was not fully achieved, i.e. not many contributions were gathered into WePWEP. However, this stage served to present the developed prototype as an innovative tool for public participation in strategic planning; to gain opinions on WePWEP; and to observe that, indeed, it has the potential to engage members of the public (or of a group) in thinking about and discussing wind energy and wind farm siting issues.

Finally, the experiment to assess formally WePWEP was described. Its design was "fine-tuned" with aspects emerging from the pilot test and also difficulties mentioned by previous users of the system. Results from the evaluation stage are presented and discussed in the next chapter.

Chapter VIII

WePWEP evaluation: results and discussion

VIII.1. Introduction

This chapter presents and discusses the outcome of the experiment to assess WePWEP as a fostering and leaning-enhancing system, described at the end of the previous chapter (section VII.5). The following points are addressed in successive sections:

- who participated in the experiment?
- how participants in the experiment have used WePWEP?
- what is their feedback on the system, particularly regarding learning, difficulties experienced and recommendations for improvement?
- what are their views on the principles behind WePWEP development?
- their contributions for the selected case study, i.e. wind farm siting.

At the end of each section, significant results are pulled together and discussed and, whenever possible, tentative conclusions are advanced. The chapter concludes with a highlight of the most relevant aspects presented and discussed throughout and a few lessons learnt. These are potentially useful to guide the design of web-based public participation systems in general. Unexpected contributions by the participants to the case study problem are also summarily identified.

VIII.2. Who participated in the event?

The experiment to evaluate WePWEP was conducted at the School of Environmental Sciences, UEA. Twenty-eight participants were recruited amongst staff and post- and undergraduate students. Twenty received a reward for their participation in the experiment; eight acceded to participate without pay. The following sections characterise the participants based on information provided during the registration process. The purpose is to investigate to what extent participants in the experiment are representative of public in general and the likely users of WePWEP if it were released online, so conclusions can be drawn regarding to what extent results from the experiment can be used to conclude about WePWEP and about design issues for public participation systems in general.

As registration was not absolutely required to use WePWEP (*cf.* section V.7.3), one participant decided not to register[52]. Therefore, the following description concerns exclusively to the twenty-seven participants who registered.

VIII.2.1. Gender, age and level of education

Participants in the experiment were evenly distributed with regard to gender: 51.9% female against 48.1% male - this reflects an option of the recruitment process (*cf.* section VII.5.2). Reflecting the universe of recruitment, most participants were aged between 20 and 24 (44.4%), Figure VIII.1, and had an undergraduate degree (55.6%), Table VIII.1. About one fourth of the participants (25.9%) had a postgraduate diploma.

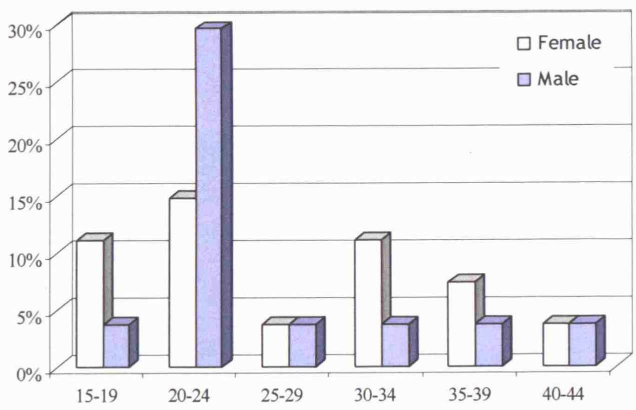


Figure VIII.1 – Age groups and gender of the participants in the WePWEP evaluation event.

[52] Participants were not explicitly asked to register, although the system informs that full functionality is only available to registered participants. The participant who did not register was not encouraged to provide a reason as the fact was only found out after the experiment, while processing the results.

It should be noted that the breadth of ages also results from the recruitment process as, to diversify the profile of participants, all volunteers identified as not students were selected. This recruitment option was made based on the assumption that, if WePWEP had been released online, various age groups of users would have used it.

Age group	Highest level of education						Total participants	
	A-level or equivalent		First degree		Postgraduate degree			
	No.	%	No.	%	No.	%	No.	%
15-19	3	11.1%	1	3.7%	--	--	4	14.8%
20-24	2	7.4%	10	37.0%	--	--	12	44.4%
25-29	--	--	2	7.4%	--	--	2	7.4%
30-34	--	--	--	--	4	14.8%	4	14.8%
35-39	--	--	1	3.7%	2	7.4%	3	11.1%
40-44	--	--	1	3.7%	1	3.7%	2	7.4%
Total participants	5	18.5%	15	55.6%	7	25.9%	27	100.0%

Table VIII.1 – Age groups and highest level of education of the participants.

It is interesting to note that one participant identified him/herself within the age group 15-19 and having a first degree. This can have been a mistake, but it highlights the need for input validation during the registration process when this information is intended for research purposes.

VIII.2.2. Geographical distribution

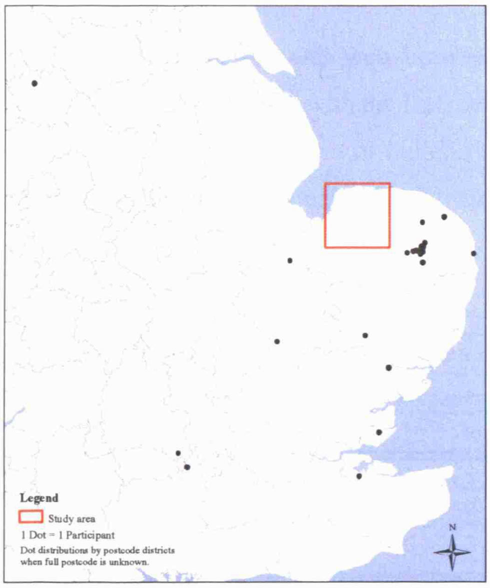


Figure VIII.2 – Geographical distribution of participants.

Participants were asked to enter their postcode district, or their parents' if students. Eleven participants entered a full postcode, one entered a postcode that could not be georeferenced and the others entered a postcode district. Figure VIII.2**Error! Reference source not found.** depicts the geographical distribution of participants in reference to the study area. The majority of participants lived in areas nearby the UEA (Norwich) but none was from the study area.

Questioned about their knowledge of the study area, most participants declared to know it little or very little. Only seven participants (25.0%) stated to know it rather well or well (marked 5 or 6 in response to the question in Table VIII.2).

		How well do you know the case study area addressed in the website?						
		don't know 1	2	3	4	5	know well 6	Total participants[1]
Participants	No.	1	10	5	5	5	2	28
	%	3.6%	35.7%	17.9%	17.9%	17.9%	7.1%	100.0%

[1]Since this questions was part of the feedback form and not login, all participants answered it.

Table VIII.2 – Participants' knowledge of the case study area.

VIII.2.3. Computer and Internet literacy

As expected due to the universe of recruitment, most participants are computer literate and frequent users of the Internet. Twenty-two participants (81.5%) stated that computers are part of their everyday life, and the remaining five declared to feel reasonably comfortable using them in a variety of tasks. As for the use of Internet, all but one participant (96.3%) stated to use the Internet on a daily basis. This participant stated to use the Internet once or twice a week.

Clearly, participants are familiar with computers and web browsers. To investigate a little further the level of interactivity that participants have with the Internet, they were asked whether they had ever participated in an online discussion forum or bulletin board. Table VIII.3 shows the participants' responses, cross-tabulated with the frequency of Internet use.

Have you ever participated in an online discussion forum/bulletin board?	Frequency of Internet use				Total participants	
	Daily		Once or twice a week			
	Participants		Participants			
	No.	%	No.	%	No.	%
Yes	8	29.6%	1	3.7%	9	33.3%
No	17	63.0%	--	--	17	63.0%
Prefer not to answer	1	3.7%	--	--	1	3.7%
Total participants	26	96.3%	1	3.7%	27	100.0%

Table VIII.3 – Participation in a discussion forum/bulletin board and frequency of Internet use.

The majority of participants (63%) had not participated in an online discussion. Interestingly, the participant who declared to use the Internet less frequently had done so.

VIII.2.4. Competences on map interpretation

WePWEP includes several maps conveying relevant information for decision-making (e.g. impacts on evaluation criteria). When questioned about their skills or comfortableness in interpreting maps, only one participant declared to lack the experience to feel conformable at this task. All others expressed to feel either very or reasonably comfortable with it, Table VIII.4.

How comfortable are you interpreting maps?	Participants	
	No.	%
Very - I am used to it	13	48.1%
Reasonably - I need some time	13	48.1%
Not very - I lack experience	1	3.7%
I am not - I hardly read maps	--	--
Prefer not to answer	--	--
Total participants	27	100.0%

Table VIII.4 – Participant's ability in understanding maps.

VIII.2.5. Views of wind energy

During registration participants were also questioned regarding their concern about the environment and a few aspects related to wind energy. The purpose was to perceive their general knowledge and attitude towards wind energy technology.

All participants stated that they were concerned with the environment: twenty-three participants (85.2%) declared to be very concerned and four (14.8%) slightly concerned. Moreover, five participants were members of an environmental organisation. Although, in general, people are increasingly concerned with the environment (partly due to a greater awareness of the consequences of human actions (e.g. global warming) and limited natural resources such as unsalted water), these results clearly reflect the recruitment universe: a School of Environmental Sciences.

Questioned about their knowledge on wind energy issues, most participants declared to "know a little". Only four participants acknowledged to be well informed about wind energy as shown in Table VIII.5. Despite that, fifteen out of the 27 participants (over 55%) stated to have visited a wind farm in the past five years, and two declared to be able to see a wind turbine from their home.

How much do you know about wind energy?	Participants	
	No.	%
Well informed	4	14.8%
Know a little	19	70.4%
Not much	3	11.1%
Prefer not to answer	1	3.7%
Total participants	27	100.0%

Table VIII.5 - Participants' knowledge about wind energy.

Tables VIII.6 and VIII.7 summarise the main advantages and disadvantages of wind energy expressed by the participants (participants' terms were kept). Although they were asked for "the main advantage" and "major concern", several participants indicated more than one of each.

Main advantages of wind energy	No. participants who mention it
Clean energy / Pollution-free	8
Renewable energy	8
Low carbon emissions	6
Environmental friendly	3
Minimal environmental impact	2
Reduction in reliance on fossil fuels	2
Helps combat climate change	2
Sustainable energy	1
Ease to decommission	1

Table VIII.6 – Principal advantages of wind energy from the participants' perspective.

Major concerns related to wind energy	No. participants who mention it
Visual impacts	6
Number of turbines required to produce substantial quantities of energy	4
Partial solution - may not be able to replace fossil fuels entirely	4
Cost of electricity	2
Interference with radar	2
Lack of ability to generate a constant supply of energy	1
Lack of efficiency	1
Public opposition	1
Noisy for the neighbourhood	1
Slight destruction of environment	1
Wildlife damage	1
Not reaching the potential and levels of energy promised	1
Risk of excessive private profit of public resource	1
Energy generated may not worth the energy costs (manufacturing the blades, ...)	1

Table VIII.7 – Participants' major concerns associated to wind energy.

Clean and renewable energy are the advantages mentioned by the largest number of participants. Visual impact, the large number of turbines required to producing a significant amount of energy, and how much energy needs can be met by wind energy are the participants' greatest concerns.

It is worth noting that pointing out an advantage and a concern was not compulsory. Despite that, only one participant did not do it. This reflects the interest of participants to contribute to the study and some background knowledge on the technology, as they acknowledged.

VIII.2.6. Discussion

Twenty-eight people, recruited from the School of Environmental Sciences from the UEA, took part in the WePWEP evaluation experiment. Briefly, this group can be described as young, educated, familiar with computers and the Internet, and concerned with the environment. Most participants had some background knowledge on wind energy, more than a half had visited a wind farm in operation and none had an obvious negative attitude towards the technology. These characteristics, reflecting the universe of recruitment, cannot be argued representative of the whole UK population.

Haklay (2002) states that the likely audience for online environmental information systems is educated, literate, comfortable with the use of the Internet and more active in environmental issues than the average population. Extending this finding to online participation systems, it can be derived that, despite not being representative of the UK population at large, the group of participants involved in the experiment can be representative of the potential users of WePWEP if it were launched on the Internet. From this perspective, participants' evaluation of WePWEP can be taken as an approximation to that of the potential "public users" of WePWEP. Consequently, results from the experiment can be used to conclude about the fulfilment of the WePWEP's goal from the point of view of its likely Internet-based audience. However, careful interpretation of results is required to infer about WePWEP as a tool for laypeople to participate in spatial planning and about design aspects for public participation systems.

Participation in spatial planning implies handling maps and participants typically know the area in discussion. During discussion or development of a planning proposal, participants tend to manipulate the map(s) to identify familiar spatial references (places, landmarks, ...) and, most likely, keep an eye on their particular area(s) of interest. Participants in the experiment declared to be able to interpret maps, although some time may be required. Unfortunately, the majority declared to know little the study area. This implies that they will potentially approach the planning problem at hand from a "non-personal" point of view and, therefore, will not be making very much use of the maps (as they have no particular area of interest). Moreover, no conclusions will be possible regarding the existence of NIMBYism in their contributions.

VIII.3. How did participants use the system?

Results presented in this section are based on the joint analysis of data captured by the participant's tracking mechanism (*cf.* section VI.10.3); the videos of the interaction participant-WePWEP; and notes taken during the hands-on sessions. The goal is to understand how participants have used the system so conclusions can be made regarding:

- the interest of WePWEP tiers, which is related to their ability to engage people in learning;
- the link between the second and third tier, which was hypothesised to contribute to learning;
- WePWEP's tiers perceptibility and usability; and
- links that could/should be created between tiers and webpages to facilitate the users' access to information and foster reconstruing (i.e. learning).

Throughout this section, time spent on a webpage is considered a proxy for its interest. Noteworthy, this embeds two difficulties. Firstly, the proxy is "blind" to the possibility of participants to know already what is discussed on the webpage. Secondly, it does not take into account the length of the page (i.e. number of words) or whether it contains input forms and/or maps. Since there is no viable way to work around the first problem and, if the second aspect is kept in mind when interpreting data, the proxy can, nevertheless, be meaningful.

VIII.3.1. Total time into the system

Although sessions were designed to last for a maximum of one hour, on average, participants used WePWEP for approximately one hour and twelve minutes[53], Table VIII.8. The shortest session lasted for about forty-three minutes (participant 21) and the longest session for almost two hours (participant 13). Data on individual use of the system is available in Appendix B, both disaggregated by WePWEP page and grouped by registration and tiers as in Table VIII.8.

[53] It was possible to accommodate sessions longer than one hour because several computers were available. Participants were informed that their session time had expired but those willing to continue were allowed to.

	Time spent in					
	WePWEP	Registration	1st tier	2nd tier	3rd tier	4th tier
Average	01:12:31	00:04:04	00:19:28	00:21:01	00:13:41	00:14:15
Standard deviation	00:16:40	00:01:44	00:13:56	00:11:48	00:08:28	00:07:10
Maximum	01:53:40	00:09:40	00:50:40	00:46:33	00:34:45	00:27:19
Minimum	00:43:19	00:00:09	00:01:32	00:03:49	00:00:00*	00:02:34

* One participant did not visit the 3rd tier.

Table VIII.8 – Statistics on time spent by participants in WePWEP and each of its tiers (refer to Figure B.1 in Appendix B for specification of the webpages comprised in each tier).

Time spent on the three main tiers was fairly balanced as Figure VIII.3 shows:

- about twenty minutes (27% of the average session duration) exploring background information in the first tier;
- approximately twenty-one minutes (29%) developing a personal proposal for wind farm siting in the second tier; and
- nearly fourteen minutes (19%) exploring contributions and the "social" classification of feasible sites within the third tier.

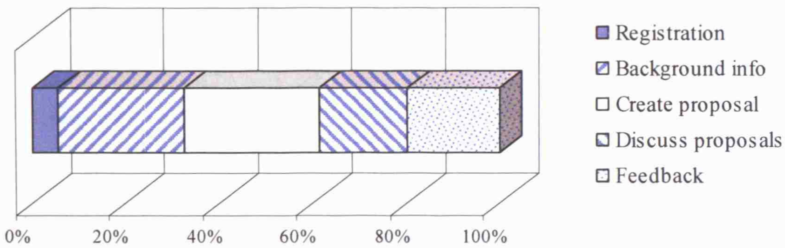


Figure VIII.3 – Breakdown of the sessions' average time.

Significant amount of time was spent in the first tier. This result was quite surprising because (1) before the experiment, participants were sent a PDF file with the information available in this tier and recommended to read it (*cf.* section VII.5.2); and (2) they had been informed (indirectly) that the following tiers would be more interactive – this piece information was supplied as justification for reading the PDF file beforehand.

Figure VIII.4 relates the time spent in the first tier and the participants' response regarding having read the PDF file prior to the experiment (*cf.* section VII.5.3).

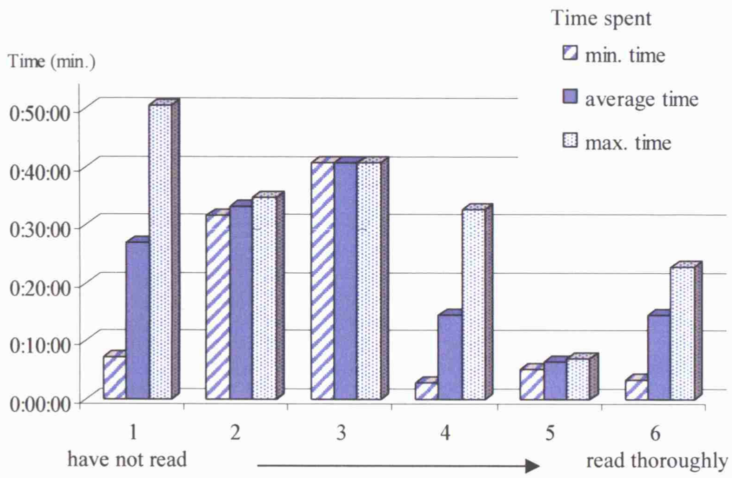


Figure VIII.4 – Relation between time spent in WePWEP's first tier and having read the background information supplied prior to the experiment.

It shows that participants who had read the PDF file more thoroughly beforehand have spent, generally, lesser time in the first tier. However, there is not a strict relation between these variables – participants who responded level 3 (as in Figure VIII.4) to having read the PDF file, spent on average longer in WePWEP's first tier than those who acknowledged not having read the file. Reassuring is that, participants who spent the longest in the first tier stated not to have read the PDF file (e.g. participant 19 who spent over fifty minutes on it; participant 27 who spent almost forty-nine minutes; and participant 15 who spent just over forty minutes - *cf.* Table B.1, Appendix B).

VIII.3.2. Usage of the first tier: "Background information"

Table VIII.9 compiles some statistical data on how participants have used WePWEP's first tier: the number and percentage of participants who have visited each webpage or group of webpages, the average time spent on them (μ), standard deviation (σ), maximum (max) and minimum (min).

All 28 participants had been on the information area portal, i.e. 'Wind energy and wind farm siting' webpage. The three information topics provided seem to have attracted the participants' interest:

- 93% entered the section wind energy, with one participant spending nearly half an hour on it;

- 86% visited the section wind farm siting; and
- 89% wanted to learn about wind energy in Norfolk; from these, over than 50% (13 out of 25) went forth to learn details of wind farm projects proposed for Norfolk (approved and not approved).

1st tier						
Webpage / Webpages group	Participants who visited it		Time spent on it			
	No.	%	μ	σ	max	min
The initiative*	19	67.9%	0:00:26	0:00:36	0:02:26	0:00:02
The website	27	96.4%	0:01:10	0:00:33	0:02:18	0:00:27
Wind energy & wind farm siting	28	100.0%	0:01:09	0:00:35	0:02:56	0:00:14
Wind energy**	26	92.9%	0:07:20	0:07:17	0:28:27	0:00:08
Wind farm siting**	24	85.7%	0:04:28	0:04:34	0:16:32	0:00:03
Wind energy in Norfolk**	25	89.3%	0:07:01	0:04:36	0:16:04	0:00:02
Details of wind farm projects**	13	46.4%	0:01:55	0:01:20	0:04:34	0:00:32
Total 1st tier	--	--	0:19:28	0:13:56	0:50:40	0:46:33

* This is WePWEP initial page. Figures do not consider the use of this webpage as initial page.

** Figures include any participant that has, at least, visited one webpage within the group.

Table VIII.9 – Statistic data on usage of the WePWEP 1st tier.

To explore this information one step further, the most popular webpages within each webpages group were examined. As Table VIII.10 shows, 'Facts & figures' and 'Why wind energy?' were the most popular webpages within the section 'Wind energy', respectively with 93% and 79% of the participants visiting them. 'The debate' and 'Public opinion' received one less visit (75% of participants) but, on average, held longer the participants, meaning that those who visited them found them interesting. 'The debate' webpage, in particular, was found fairly interesting: on average, it absorbed the participants' attention for almost three and a half minutes, the longest average period within a first tier's webpage. This page presents arguments in favour and against wind energy.

Webpages groups of 1st tier							
Webpages group	Webpage	Participants who visited it		Time spent on it			
		No.	%	μ	σ	max	min
Wind energy	Facts & Figures	26	92.9%	00:01:23	00:01:21	00:05:11	00:00:03
	Why?	22	78.6%	00:01:09	00:00:58	00:02:52	00:00:02
	The debate	21	75.0%	00:03:21	00:03:06	00:10:32	00:00:04
	Public opinion	21	75.0%	00:01:36	00:02:32	00:11:58	00:00:02
	Learn more	8	28.6%	00:03:08	00:03:56	00:13:08	00:00:13
Wind farm siting	A feasible site	22	78.6%	00:02:35	00:02:56	00:09:53	00:00:03
	Planning application process	20	71.4%	00:01:22	00:01:13	00:04:13	00:00:02
	Public involvement	19	67.9%	00:00:41	00:00:38	00:02:26	00:00:02
	Learn more	9	32.1%	00:01:07	00:01:58	00:06:17	00:00:03
Wind energy in Norfolk	Location of approved wind farms	21	75.0%	00:01:41	00:01:16	00:04:44	00:00:06
	Ecotech planning application process	23	82.1%	00:01:45	00:01:18	00:05:43	00:00:03
	Swaffham II planning application process	22	78.6%	00:02:23	00:01:57	00:06:41	00:00:02
	Learn more	12	42.9%	00:01:51	00:02:47	00:08:42	00:00:02
Details of wind farms proposed for Norfolk	Details of approved wind farms*	13	46.4%	00:00:50	00:00:48	00:03:01	00:00:05
	Location of wind farm projects not approved	7	25.0%	00:00:31	00:00:17	00:01:02	00:00:09
	Briefing of wind farms projects not approved**	7	25.0%	00:01:30	00:00:56	00:03:31	00:00:29

* Group of 8 webpages, each referring to an approved wind farm.

** Group of 10 webpages, each referring to a wind farm that has not been approved.

Table VIII.10 – Statistic data on usage of the information sections within the 1st tier.

Within the section 'Wind farm siting', the most popular webpages were 'A feasible site' and 'The planning application process', respectively with 22 (79%) and 20 (71%) participants visiting them. The former attracted participants for the second longest average duration: a little over two and a half minutes. This webpage discusses the aspects that need to be considered when locating a wind farm (e.g. distance to dwellings and proximity to the grid network).

Unexpectedly, not all participants visited the group 'Wind energy in Norfolk': 21 participants (75%) visited the page 'Location of approved wind farms', and 23 (82%) and 22 (79%) participants visited the Ecotech and Swaffham II planning application process webpages, respectively. This slightly higher number of visits is due to a direct link to these webpages from 'The planning application process' webpage in the 'Wind farm siting' section (*cf.* Figure B.1. Appendix B). These links are offered in there as illustration of the planning application process applied to real-word situations. Time spent of these pages suggests that participants found them interesting.

Out of the 21 participants who visited the 'Location of approved wind farms', thirteen examined details of, at least, one approved wind farm project, and seven inspected the location and details of, at least, one non-approved (i.e. planning application refused or withdrawn by the applicant) project. On average, participants examined 2.3 approved projects, with a maximum of four (out of eight). The projects that attracted more interest were Swaffham II and the offshore development Scroby Sands, each with seven visits. Ecotech wind turbine and the offshore wind farm at Cromer (currently under construction) also rouse some interest (six and four visits respectively).

Regarding non-approved projects, on average, participants explored details of 2.6 projects, with a maximum of five (out of ten). Not surprisingly, Shipdham and Guestwick were the projects that received the greatest interest (respectively with five and two visits). These are the most recent Norfolk's refused wind energy proposals, both with a final decision issued after Public Inquiry. The small number of participants that visited these webpages (seven) may be due to (1) access to them is only possible through the webpage 'Location of approved wind farms'; and (2) via a discrete link. As one participant noted:

> "The link to these pages should definitely be made more evident, using a button, for instance. Right now, it is very easily missed out and it gives access to great stuff" (Participant 28)

Finally, it is interesting to note that participants did visit the 'Learn more' webpages; and some explored external resources for a reasonable amount of time (*cf.* Table VIII.10) before returning to WePWEP. This suggests that participants adopted a proactive approach towards learning and, design-wise, confirms that (1) providing links to related and/or supporting resources and (2) opening outwards links in new webpages while the system's webpage waits in background are good options for public participation systems. Links to external resources transmit some sense of freedom and credibility to the participant, without necessarily losing him/her.

Within the tier participants navigated preferentially using the navigation menu and links provided, instead of the 'Back' and 'Next' page buttons. Regarding to these, two participants noted that:

> "(...) Using the 'next' buttons makes it feel as if you must read everything and this can seem oppressive." (Participant 10)

> "(...) I am unsure of the use of the 'next' feature to go to the next page in the background section, the level of information was quite hard to digest. (...)" (Participant 13)

No particular difficulties were observed while participants used WePWEP's first tier or assistance was requested. From the usability point of view, this suggests that the first tier is adequate for its potential users (*cf.* section VIII.2.6).

VIII.3.3. Usage of the second tier: "Create your proposal"

Table VIII.11 shows statistical data on usage of WePWEP's second tier. Average time (μ), standard deviation (σ) and maximum time (max) spent on webpages are presented only for the tier's main webpages and 'Weighing sub-criteria' webpages. All other webpages open in pop-up windows and their closing time is only acquired when the participant closes them using the 'Close' button provided on the upper left corner of the page. As most participants closed them using a different mechanism, time spent on these pages could not be determined.

All participants visited the 'Feasible sites' and 'Criterion *i*' webpages; however, three did not create a personal classification of feasible sites: participant 6, who did not log in; participant 15, who only flipped through the second tier (her total time spent on this tier was less than four minutes – the shortest time, *cf.* Table B.1, Appendix B); and participant 16. The route of participant 16 within the tier is rather interesting: she weighted all evaluation criteria, examined details of many sub-criteria, changed the default weights of some, but, as she did not visit the 'Classification' webpage, no personal classification was generated (*cf.* Figure B.17, Appendix B). The video of her session reveals that she "walked" through the second tier using preferentially the navigation menu instead of 'Back' and 'Next' page buttons. Thus, one can wonder if she was aware of the importance of the 'Classification' webpage. This situation raises two discussion points. One regards the clarity of the process taking place throughout the second tier. The other respects the way navigation in the tier is permitted. These points are discussed ahead, in section VIII.3.5.

Regarding the time spent on each webpage (a proxy for its interest), participants spent, on average:

- over three and a half minutes on the 'Feasible sites' webpage;
- more than two minutes on 'Criteria *i*'-type webpages; and
- almost three minutes on the 'Classification' webpage.

As these webpages have little text, it is assumed that participants focused on observing the map and making sense of their tacit knowledge and values to decide on their input. Longer time spent on the 'Feasible sites' webpage may reflect longer map exploration. If this is the case, maps seemed to lose prominence (i.e. they were lesser and lesser manipulated) as participants progressed through the tier. This can be due to participants knowing already what to encounter on maps. In the tier's last webpage ('Classification'), the map seems to regain importance: its interpretation motivated 65% of participants (17 out of 26) to re-adjust their stated preferences. On average, participants created 2.1 classifications, with a maximum of five, by participants 5 and 22.

		2nd tier				
Webpages group	Webpage	Participants who visited it		Time spent on it		
		No.	%	μ	σ	max
	Introduction	27	96.4%	0:01:19	0:00:46	0:03:33
	Feasible Sites	28	100.0%	0:03:39	0:02:49	0:11:04
About identifying feasible sites	Methodology	4	14.3%	--	--	--
	Criteria for delimitation	3	10.7%	--	--	--
	Applying the criteria	2	7.1%	--	--	--
	Criterion 1	28	100.0%	0:02:53	0:02:16	0:09:36
About sub-criteria involved in criterion 1	Sub-criterion 1	11	39.3%	--	--	--
	Sub-criterion 2	6	21.4%	--	--	--
	Sub-criterion 3	6	21.4%	--	--	--
	Sub-criterion 4	5	17.9%	--	--	--
	Sub-criterion 5	7	25.0%	--	--	--
	Weighting sub-criteria	8	28.6%	0:02:31	0:01:10	0:04:52
	Criterion 2	28	100.0%	0:01:44	0:02:09	0:11:15
About sub-criteria involved in criterion 2	Sub-criterion 1	2	7.1%	--	--	--
	Sub-criterion 2	6	21.4%	--	--	--
	Sub-criterion 3	5	17.9%	--	--	--
	Weighting sub-criteria	1	21.4%	0:01:45	0:01:07	0:03:25
	Criterion 3	28	100.0%	0:02:12	0:02:35	0:12:41
About sub-criteria involved in criterion 3	Sub-criterion 1	4	14.3%	--	--	--
	Sub-criterion 2	7	25.0%	--	--	--
	Sub-criterion 3	3	10.7%	--	--	--
	Weighting sub-criteria	8	28.6%	0:01:27	0:01:25	0:04:10
	Criterion 4	28	100.0%	0:02:09	0:01:56	0:06:49
About sub-criteria involved in criterion 4	Sub-criterion 1	5	17.9%	--	--	--
	Sub-criterion 2	7	25.0%	--	--	--
	Sub-criterion 3	6	21.4%	--	--	--
	Sub-criterion 4	5	17.9%	--	--	--
	Weighting sub-criteria	8	28.6%	0:02:36	0:02:52	0:09:51
	Criterion 5	28	100.0%	0:01:46	0:01:47	0:08:03
About sub-criteria involved in criterion 5	Sub-criterion 1	6	21.4%	--	--	--
	Sub-criterion 2	1	3.6%	--	--	--
	Sub-criterion 3	5	17.9%	--	--	--
	Sub-criterion 4	5	17.9%	--	--	--
	Weighting sub-criteria	7	25.0%	0:02:07	0:02:08	0:06:48
	Classification	26	92.9%	0:02:47	0:02:20	0:09:19
About classification of feasible sites	Classification method	6	21.4%	--	--	--
	Performance normalisation	0	0.0%	--	--	--
	Criterion types	0	0.0%	--	--	--
Total 2nd tier		--	--	0:21:01	0:11:48	0:46:33

Table VIII.11 – Statistic data on usage of the WePWEP 2nd tier.

Noteworthy, no secondary page received more than seven visits (27% of participants). This makes it clear that the typical user of WePWEP will not look up details of the system, such as how the feasible sites have been identified; what is the real meaning of the sub-criteria; how performances on them have been assessed; and how classification of feasible sites is computed. Instead, they will construct "their own picture" from the information provided in the main webpages. Not aware of the assumptions and procedures behind what they are doing, it is expectable that doubts similar to the one below will raise:

> "How are 'Visual impact' and 'Impact on landscape' different? It seems this feature has a double weighting (…)." (Participant 20)

With regard to design of public participation system, this point seems to highlight that crucial information for the understanding of the task at hand needs to be provided in the main pages. However, the ability to discriminate between crucial and less (non-) crucial information is not a easy matter, especially when it has to be balanced with the space available in a webpage.

Unlike in the first tier, the 'Back' and 'Next' buttons were quite popular to navigate throughout the second tier. Possibly because participants understood the sequential nature of the process and/or due to their strategic location on the webpage: always visible, right below the form that collects the participant's input.

Map manipulation by the participants was not consistent throughout the tier. Participants' most frequent interaction with the map was to make a map layer visible/invisible. Map tools to focus on a specific location (e.g. zooming tools) were hardly used, likely consequence of participants' little knowledge of the study area (*cf.* section VIII.2.6). While manipulating the map, three participants requested the facilitator's assistance. Two wanted to know why the raster maps indicated in the TOC were not visible and how to make them visible. The other questioned about the functionality of the information button offered as a map tool. These questions, obvious for those familiar with GISs, highlight the fact that using technical tools as basis for development of systems intended to laypeople will often raise difficulties.

As planned (*cf.* section VII.5.3), the observer/facilitator also intervened when it became noticeable that participants have not realised what was behind the link 'overall *x* impact' (*cf.* Figure VI.6). Participants were invited to click on this link to open the 'Weighting sub-criteria' webpage and then a short explanation of the webpage was provided. This explanation was given only for one criterion, and generally participants mentioned it to be an interesting functionality. Despite that, few (three out of eleven) accessed to similar webpages afterwards (*cf.* Table D.2, Appendix D). Various justifications can be put forth for that. A plausible one is that participants found it too burdensome engaging with such level of detail in the decision-making process (this is the assumption behind the pre-weighting of sub-criteria). Nevertheless, according to some participants, it is probably worth to make access to these webpages more obvious – for instance, using a button instead of a link.

VIII.3.4. Usage of the third tier: "Discuss proposals"

Table VIII.12 shows statistical data on the usage of WePWEP's third tier. All participants but one visited the 'Introduction' webpage; from these, all but one proceeded to the AM. The average time spent on the AM by participants was approximately fourteen minutes, with a maximum of over thirty-three minutes.

		3rd tier				
Webpages group	Webpage	Participants who visited it		Time spent on it		
		No.	%	μ	σ	max
	Introduction	27	96.4%	00:00:51	00:00:43	00:04:01
	Argumentation map	26	92.9%	00:13:52	00:07:44	00:33:35
How to use the argumentation map?	Discussion	19	67.9%	--	--	--
	Map layers	13	46.4%	--	--	--
	Social classification & controversy map	7	25.0%	--	--	--
	Map tools	6	21.4%	--	--	--
	Search and analyse	7	25.0%	--	--	--
	Submit help request	0	0.0%	--	--	--
Total 3rd tier		--	--	00:13:41	00:08:28	00:34:45

Table VIII.12 – Statistic data on usage of the WePWEP 3rd tier.

From the twenty-six participants that used the AM, nineteen (73%) accessed the 'How to use the argumentation map?' webpages group. This suggests that "getting the grip" of the AM can be complex. 'Discussion' webpage is the group's opening page. This likely justify why it has more visits than other pages, instead of reflecting a greater complexity of this interface component.

On the other hand, it is interesting to note that significantly fewer participants consulted the group's webpages 'Map tools' and 'Search and analyse'. A possible reason for this is that participants looked for assistance on a visual/schematic format and it was provided in textual form. This might have discouraged them to seek further assistance. Nevertheless, this pattern is consistent with the observed usage of the AM: virtually all participants browsed the discussion forum; some experimented with the visibility of map layers; but only a few used the map tools or tried a search and analyse functionality.

Sessions observation also revealed that finding out how to expand compressed threads in the discussion forum was not obvious for several participants – this was somewhat unexpected as the tree structure is fairly ubiquitous in the computers domain. While some participants worked it out after inspecting the 'Discussion' page in the assistance webpage group; others did not look for any sort of assistance – maybe they did not realise that some threads were compressed. When this behaviour was perceived by the observer/facilitator, an explanation of the basic functionality of the discussion forum was provided and the participant was encouraged to visit the 'Discussion' webpage. A measure to make compressed threads more obvious is to re-design the AM with a look and feel closer to that of the Windows® operating system.

On a less systematic basis, the observer/facilitator also drew the participants' attention to the use of the 'select contributions by spatial reference' tool to explore discussion contributions which was being under-used.

Furthermore, observation of the participants interaction with the AM made clear that some had difficulties in understanding which 'feasible sites' were visible on the map viewer: whether the "social" classification, the associated controversy or their personal classification. When this situation was noticed by the observer/facilitator, she clarified it and encouraged the participant to compare their personal classification with the "social" one.

Nine participants added a contribution to the AM's discussion forum (*cf.* Table D.4, Appendix D; see also section VIII.6.2); however, none attached a spatial reference. Examination of contributions shows that only one contribution makes reference to geographic features:

> "The approach by road, from Norwich, to Swaffham is made visually attractive by the location of the two wind turbines that can be seen." (Participant 2)

This contribution replies to an existing one that spatially refered the Swaffham II wind turbine location; maybe for this reason, the author decided not attach any spatial reference. Nevertheless, references from the "parent" contribution are not copied to its replies; this enables each participant to fully shape their contribution. It is worth noting that this participant was the only one who attempted to sketch a spatial reference (although after having submitted their contribution). This reassures that even users unfamiliar with AM can grasp the idea behind them.

Finally, the button 'Revise personal classification' in the 'Argumentation map' webpage (*cf.* section VI.8.3) passed somewhat inconspicuous: only six participants (23%) used it. From these, four did redo their personal classification. These occurrences confirm the interest and synergies arising from linking an SDSS and an AM: after having inspected the debate on the topic and learnt from submitted contributions, a participant may re-think their posture (constructs) and refine an earlier submitted proposal.

VIII.3.5. Discussion

Over the previous sections, usage of WePWEP was analysed from three points of view: time spent on each tier and respective webpages; observed interaction with tools and functions available in the system; and perceived difficulties by the participants in using the system. While presenting the findings, significant issues were discussed. This section summarises the findings and, in an integrated way, discusses their meaning regarding future versions of WePWEP and public participation systems in general.

Deriving from the time that participants spent using WePWEP, the system was concluded to be an interesting resource. Indeed, despite having been assigned to sessions of one hour, participants spent, on average, one hour and twelve minutes using WePWEP, and twelve participants (43%) spent longer than that, with a maximum of one hour and fifty-three minutes.

From the time spent by participants on each tier, the three main tiers were considered to have a similar level of interest. The slightly shorter average time spent on the third tier can be due to the approaching end of the session (one hour was about to elapse), and does not necessarily reflect a less interest by the participants. However, it must be noted that all tiers are very different, and the second and the third tiers created some difficulties to the participants, so time was spent in getting around these problems. Moreover, it must be acknowledged that participants were taking part in an experiment (where a small reward was involved), and because of that they possibly endured the difficulties and continued using WePWEP. Challenging this argument, one can point out that, when approaching any new system, there is always a learning curve and if there is an interest on the process or/and outcome, the user does not simply forsake the system when difficulties arise. WePWEP is a public participation system, and this implies that it is going to be used by people interested in having their say in the planning process.

In the first tier, participants found equally interesting the three topics covered: wind energy; wind farm siting and wind energy projects in Norfolk. Within the first topic, the most appealing page was that presenting arguments for and against wind energy. On the second topic, the most popular page identifies the aspects that developers look at when searching for suitable/feasible sites for a wind farm. Regarding the third topic, the description of the planning application process of the Ecotech and Swaffham II wind turbines attracted the most attention. Contrasting to expectations, not all participants visited the webpages with information on local wind farm projects, but those who did it, spent some time examining the details of approved and refused or withdrawn projects. Some participants explicitly mentioned the interest of this information and recommended making the access to these webpages clearer. Also unexpectedly, around 30% of participants explored the 'Learn more' webpages. This suggests that participants have not adopted a passive attitude towards given information; conversely, it seems like WePWEP succeeded in stimulating thinking and the will to seek further information.

Participants navigated the first tier mostly using the navigation menu and links provided, which allow more flexibility and freedom that that possible through the 'Back' and 'Next' page buttons. A couple of participants noted that provided buttons are not suitable for the tier's navigation because they "push" the users to read all the information, which is a lot and "hard to digest". Overall, about the fist tier it is possible to conclude that (1) it informs and stimulates learning; and (2) its design is suitable for laypeople with basic knowledge of Internet navigation.

Regarding the usage of the second tier, the most striking aspects are the relatively poor usage of maps and the low access to secondary webpages to learn details about the decision-making process at hand. While the former can be justified by the poor knowledge of the study area and, therefore, no particular interest on the maps (*cf.* section VIII.2.6); the latter has important implications on the design of public participation systems. It suggests that the designer cannot rely on the good will of the system's users to look up relevant information; this information has to be visible.

The decision-making process underlying the tier is considered relatively clear as most participants successfully generated their own classification of feasible sites. On average, participants revised their classification once and, while progressing on the tier, some returned back to criteria pages to re-state entered weights. This indicates that learning took place throughout the process and, as anticipated, the SDSS acts well as a "laboratory" where participants can explore and crystallise their tacit knowledge, constructs and values.

As noted in section VIII.3.3, participant 16 usage of the second tier is rather peculiar: after having weighed all evaluation criteria and some sub-criteria, she moved onto the third tier without visualising the result of her contribution. She might have thought that, irrespective to the results, she has expressed her views. Nevertheless, it makes one wonder if she fully grasped the whole decision-making process and/or realised what can be done on the 'Classification' webpage. From the perspective of Kelly's learning theory, this webpage is the evidence that enables individuals to (dis)confirm a construct and complete their learning cycle (*cf.* Figure II.1). Indeed, it has led several participants to reconstruing (i.e. generate a new classification). From the design point of view, the described situation raises the question whether restricting navigation within the tier to sequential buttons is a better option, to ensure that participants go through all stages of the process. Carver and his colleagues implemented this option in their OSDM systems (Carver *et al.*, 1996; 2002a). Personally, I think that flexibility of navigation should be offered, although the use of sequential buttons should be encouraged (by strategically positioning the 'Next' and 'Back' buttons in the webpage). This stance is based on the fact that reaching the dis(confirmation) phase *per se* is not a guarantee for reconstruing.

In contrast to the first tier, the second tier raised some usability issues: several participants did not feel comfortable handling the maps and respective TOC, as they were not familiar with the underlying GIS technology. Nowadays there are numerous websites that embed maps; however, the most common do not include a TOC or require the users to turn map layers invisible to see the ones underneath. Therefore, the increasing of WePWEP's usability seems to be dependent on the emergence of similar tools (likely within the context of PPGIS or web-based participation in spatial planning) and users to become more familiar with the basics of GIS technology. Meanwhile, two options can be considered:

- simplify WePWEP's second tier, possibly by removing the TOC and the 'identify' tool; or/and
- create visual helps and/or pop-up windows explaining how to use the available functionalities or suggesting ways of proceed.

The latter option was proposed by participant 17 when questioned on difficulties experienced using WePWEP (*cf.* Table C.3, Appendix C). Other ways to improve the tier had also been suggested (see section VIII.4.5).

The analysis of the third tier's usage raises similar comments to those regarding the second tier. Participants experienced difficulties using the AM: opening compressed threads of the discussion forum was not obvious nor was controlling the displayed map layers. Despite that, access to help pages was rather low. In addition, available tools to explore the map, the discussion forum and to select/create spatial references to associate to a discussion contribution had limited use.

Sidlar and Rinner (2006) have examined the usability of Keβler's prototype, the AM embedded in WePWEP's third tier. They noticed that users also made limited use of advanced functionalities and concluded that "a simplification of the tool is in order". Our findings regarding usage of WePWEP's third tier reinforce this conclusion, despite requiring more from the participants (e.g. comparison between personal and "social" classifications).

Last, but not least, the learning potential of the link second-third tiers was realised by four participants who, after exploring contributions by other individuals, returned to the second tier to revise their submitted planning proposal. This "refinement" of an initial proposal puts in evidence synergies arising from combining an AM and an SDSS. The fact that only four participants (15%) realised this potential is slightly disappointing, but can be accounted for by various factors: the time constraint to use the system; the system's complexity; the poor knowledge of the study area; and possibly the relatively low number of contributions in the discussion forum, particularly with conflicting arguments, to stimulating re-thinking.

VIII.4. Feedback on WePWEP

Data presented and discussed in this section originates from the feedback questionnaire in the fourth tier and debriefing interviews conducted at the end of each session (*cf.* section VII.5.3). All twenty-eight participants filled in the questionnaire and were debriefed.

The questionnaire is a "mix bag" of close- and open-ended questions (*cf.* chapter V.6.1 and Appendix A.2.). The following analysis integrates responses to the two types of questions to give "a full picture" of the participants' perception of the system.

VIII.4.1. Learning

Participants were questioned whether they felt better informed about wind farm planning after using WePWEP. This question aimed at evaluating the system's contribution to learning. More than 70% of participants stated to have learnt while using WePWEP, as shown in Table VIII.13.

		Do you now feel better informed about wind farm planning than before you visited the website?						
		learnt nothing 1	2	3	4	5	learnt a lot 6	Total participants
Participants	No.	--	2	6	4	13	3	28
	%	--	7.1%	21.4%	14.3%	46.4%	10.7%	100.0%

Table VIII.13 – Participant's learning during while using the system.

As expected, higher levels of learning were acknowledged by those who stated to know little about wind energy and wind farm siting prior to the experiment, Figure VIII.5.

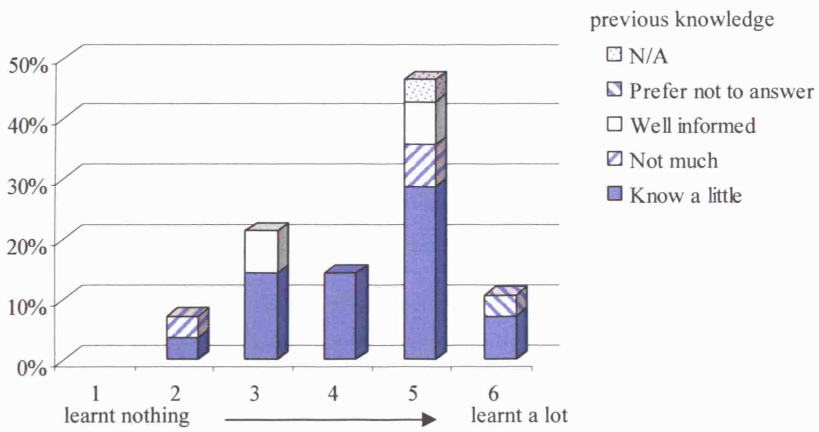


Figure VIII.5 – Knowledge on wind energy and wind farm planning issues before and after using the system.

The first tier (information area) was seen as the one that contributed the most to learning (54% of participants stated to have significantly learnt from it - learning levels 5 and 6); followed by the second tier (creation of a proposal) (39%); and the third tier (discussion of proposals), 32%, Figure VIII.6.

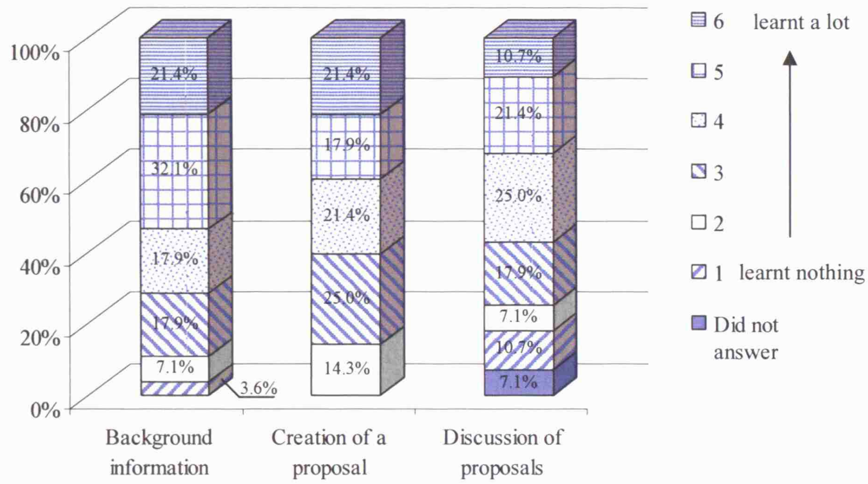


Figure VIII.6 – Contribution to learning by each WePWEP's tier.

Requested to specify how WePWEP has contributed to their learning, participants highlighted (full responses are available in Table C.1, Appendix C):

- information provided:

  "Lots of facts and figures." (Participant 17)

  "Explained the planning application procedure." and "(...) real life planning procedures are well presented and easy to read." (Participants 10 and 19, respectively)

  "Clear presentation of benefits and disadvantages of move towards wind farms." (Participant 7)

  "(...) Interesting to see the spatial distribution of wind farms that are running and those that have been rejected and why." (Participant 14)

  "It highlights the many different areas that influence windfarm planning. (...) and contains a vast source of knowledge on wind turbines." (Participant 13)

- the value of links to other resources:

  "There was lots of supported information and plenty of links to other sites to add differing arguments and opinions." (Participant 12)

- experimental learning:

"I found myself giving factors the 'most important' ranking and then thinking that the ones I hadn't chosen were equally important....it made me realise that the decisions are not easy. (...)" (Participant 16)

"(...) Actually being able to weight different criteria yourself and discuss it is a very good way of learning as well, because it makes you think about the issues that are considered in wind farm planning." (Participant 28)

- interaction with other subjects:

"(...) It was also interesting to see some of these opinions in the discussion forums, to see the sort of opposition that plans would get." (Participant 27).

Aiming at understanding if, and to what extent, the "social" classification and the associated controversy layer influenced individuals' reconstruing, participants were asked whether information provided by those maps influenced their views. Six participants (21%) acknowledged some sort of influence, but the majority (75%) refused any influence. One participant did not answer the question. Participant 6 and 17 mentioned, respectively (full comments available in Table C.2, Appendix C):

"Only very little. Knowledge of the facts had far more influence on me than knowledge of people's opinions. Controversy was possibly more interesting than social."

"I thought I was very pro-wind farms until I saw the controversy map / social and realised that they had more suitable sitings than me! (...)"

VIII.4.2. Goal achievement

WePWEP was designed with the specific purpose of fostering and enhancing learning while facilitating public participation in the strategic planning of wind farm siting. To evaluate how successful it is regarding its goal, participants were explicitly asked for their opinion. Table VIII.14 shows their responses.

The main goal of the website is to foster and enhance learning while helping to facilitate public participation in wind farm planning,								
		How well do you think the website achieves its goal?						
		fails the goal				achieves entirely		Total participants
		1	2	3	4	5	6	
Participants	No.	--	3	2	8	11	4	28
	%	--	10.7%	7.1%	28.6%	39.3%	14.3%	100.0%

Table VIII.14 – WePWEP goal achievement.

Overall participants were quite positive: four (14%) participants stated that WePWEP entirely achieved its goal and other nineteen (68%) had a favourable opinion. Three participants (11%) expressed that WePWEP nearly failed its goal.

The majority of the participants (16 out of 28) found WePWEP mostly easy to use; however a significant fraction, 36%, found it partly easy to use. Table VIII.15 relates responses to WePWEP goal achievement question and perceived ease-to-use. Interestingly, the three participants who were the least favourable to WePWEP's goal achievement have found the system relatively difficult to use (highlighted on the table).

			Did you find this site easy to use?							
			Yes		Mostly		Partly		Total	
			Participants		Participants		Participants		Participants	
			No.	%	No.	%	No.	%	No.	%
How well to you think the website achieves its goal?	fails the goal	1	--	--	--	--	--	--	--	--
		2	--	--	--	--	**3**	**10.7%**	3	10.7%
		3	--	--	1	3.6%	1	3.6%	2	7.1%
		4	1	3.6%	4	14.3%	3	10.7%	8	28.6%
		5	--	--	8	28.6%	3	10.7%	11	39.3%
	achieves entirely	6	1	3.6%	3	10.7%	--	--	4	14.3%
Total participants			2	7.1%	16	57.1%	10	35.7%	28	100.0%

Table VIII.15 – Relation between participants' responses on WePWEP ease-to-use and goal achievement.

The variables 'WePWEP's goal achievement' and 'WePWEP ease-to-use' were nonetheless found independent. For common significance levels (5% or 10%), there is not enough evidence to reject the null hypothesis 'H_0: the two categorical variables are independent'. Only assuming significance levels greater than 19.8%[54] does this becomes reasonable.

VIII.4.3. Time needed

Participants were asked about their perception on time spent using WePWEP. Most participants found that it took them too long to complete the website, Table VIII.16.

[54] The exact p value based on Pearson's statistic was calculated because the dataset did not meet the rules of thumb to use the Chi-square distribution (see Cochran, 1954; Mehta and Patel, 1996),

		What do you think about the time it took you to complete the website?							
		N/A	very little 1	2	3	4	5	too much 6	Total participants
Participants	No.	1	--	--	2	12	10	3	28
	%	3.6%	--	--	7.1%	42.9%	35.7%	10.7%	100.0%

Table VIII.16 – Perception of time spent using WePWEP.

Figure VIII.7 relates the perception on time spent using WePWEP and knowledge gained. Although the proportion of participants who declared to have significantly learnt (learning levels 5 and 6) and answered level four on perception of time spent is higher than the proportion of those who declared similar levels of learning and answered level five in perception of time spent, the two variables are independent (the computed p value based on Pearson's statistic is 0.555).

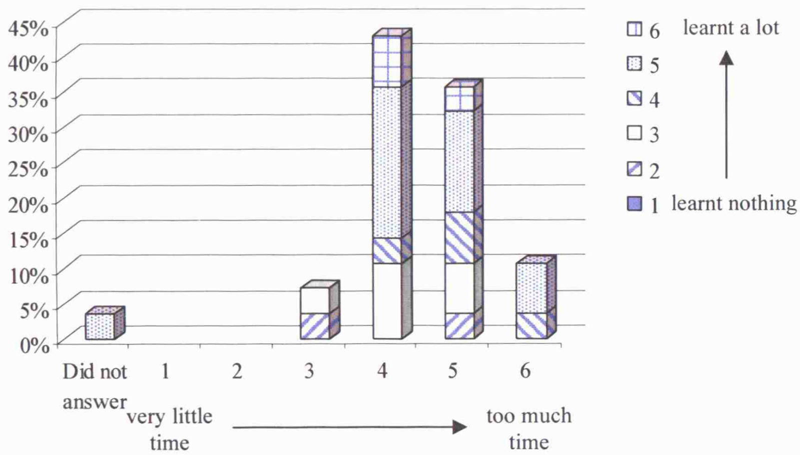


Figure VIII.7 - Relation between the participants' responses on perception of time spent using WePWEP and their learning.

Conversely, for a reasonably significance level (e.g. 10%), there is enough evidence to conclude that the participants' opinion on time spent using WePWEP is related to perceived ease-to-use (the computed p value based on Pearson's statistic is 0.0651).

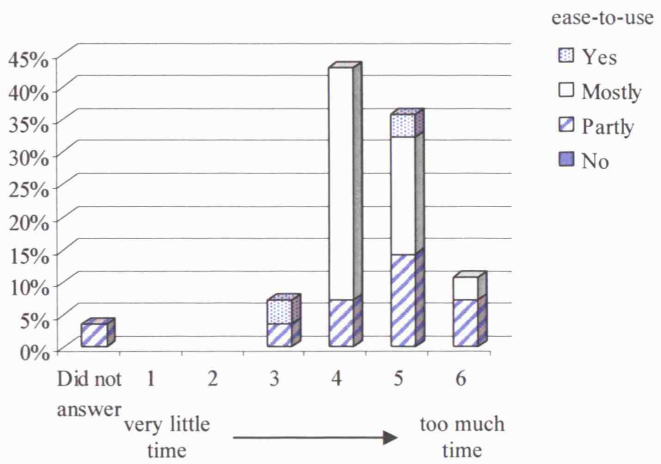


Figure VIII.8 – Relation between the participants' responses on perception of time spent using WePWEP and perceived ease-to-use.

VIII.4.4. Difficulties

Table VIII.17 lists the difficulties identified by the participants after using WePWEP (selected from the 8 choices listed).

Which parts of the website (if any) did you have difficulties with?	Participants	
	No.	%
Introduction to issues	--	--
Registration pages	2	7.4%
Links to other websites	1	3.7%
Understanding maps	13	48.1%
Create a classification of feasible sites	14	51.9%
Accessing criteria and sub-criteria details during the classification	12	44.4%
Exploring existing contributions in the discussion forum	8	29.6%
Entering a new contribution to the discussion forum	5	18.5%

Table VIII.17 – Difficulties faced by participants within the system.

In agreement to what was discussed in section VIII.3.2, the above table clearly shows that common Internet activities, such as navigating webpages, using links or fill in forms, do not represent a problem to the large majority of participants. In contrast, specific functionalities raised difficulties: about 50% of participants had difficulties in 'Create a classification of feasible sites' and 'Understanding maps'.

Participants have detailed the difficulties experienced (full comments available in Table C.3, Appendix C):

- map legends are small and difficult to read:

> "Legends need to be simplified for common usage - remove some of the legend detail." (Participant 11)
>
> "(...) found the menu[55] a little clumped and small on the side of the screen, but understand the design factors that have to be considered with screen size. (...)" (Participant 14);

- understanding overlapping map layers was not easy:

> "Not immediately clear what is being shown on the maps i.e. which layer is visible when several are ticked. Also not clear how to get the OS map to show underneath." (Participant 9)
>
> "I didn't grasp the hierarchical nature of layers at first." (Participant 25)

Regarding the process of creating a classification of feasible sites, participants noted:

> "Took me a while to understand how to contribute and interact with the maps, the rankings of the impacts (thought they have to add up to 100), how I can develop my proposal, don't know if I skipped some info, but may be an intro of how to built up/interact with the maps (i.e. that you will be using the info of the maps to rank the importance, etc...) (...)." (Participant 1)
>
> "Sometimes a little unclear due to not seeing the whole process. At the end I wasn't sure how much difference my weightings made." (Participant 10)
>
> "The classification issues were fairly complex, possibly by necessity, (...)" (Participant 18)

Participant 6 also noted:

> "(...) Was hard to know what criteria were based on - was it purely visual intrusion, was noise taken account of, did it include physical factors such as distance from roads and dwellings"

This comment reflects the uncertainty that one can feel when unaware of the details behind the decision-making process. Figure B.7, Appendix B, shows that this participant worked through the entire second tier without looking up the details and the assumptions behind any evaluation criterion.

As remarked on section VIII.3.3, accessing the webpages where sub-criteria' default weights and types could be changed was not obvious for participants. They acknowledged that:

> "(...) It wasn't really obvious how to get to the screen where the weightings of the sub-criteria were situated." (Participant 16)

[55] The participant meant TOC/legend.

Finally, specifically concerning the AM, participants commented:

> "It looked bit complicated. Also I needed to open another window to read the explanation." (Participant 24)
>
> "(...) There is a lot of information for a member of the general public to absorb here, and I think that they might find the layout of the map and forum a little difficult to get used to." (Participant 28)

This last comment is very interesting as it sums up the general feeling of participants with regard to WePWEP: somewhat difficult to use, in particular for the general public. It is worth noting that this comment reflects the type of participants and setting involved in the experiment: participants did not see themselves as "members of the general public".

Participant 2's comment also reveals the high level of education ("researcher-type") of participants in the experiment, while transmitting the same feel of complexity of WePWEP:

> "There was a lot of information to consider. I wonder if being guided through the website as a group by a moderator would make it easier to navigate and consider. It would also be useful to see how different age groups would use it. It contains a lot of technical information and terminology."

Difficulties specified by the participants do not follow a pattern. Table VIII.18 lists the five most popular responses to the question addressed in Table VIII.17. It shows that, at maximum, four participants identified the same difficulty(ies); and, interestingly an equal number of participants that did not mark any difficulty.

Rank	No difficulty	Understanding the maps	Creating classification of feasible sites	Accessing criteria and sub-criteria details during the classification	Participants	
					No.	%
1	X				4	14.3%
1		X			4	14.3%
3		X	X	X	2	7.1%
3			X		2	7.1%
3			X	X	2	7.1%

Table VIII.18 – Five most popular combinations of difficulties encountered by participants.

VIII.4.5. Further development

With regard to future improvements of WePWEP, participants were consulted about issues and information they would like to see covered in more detail. Some of the most interesting suggestions are (*cf.* Table C.4, Appendix C).

> "A summary of the impacts of the other types of plants, because at the end of the day, whether or not choose for it should be in respect with the costs of the others (...)" (Participant 1)
>
> "How the information provided through this exercise would feed into a consultation process." (Participant 2)
>
> "However, context as part of a mixed energy portfolio was not present/evident in information provided. (...)" (Participant 7)
>
> "(...) more about the current wind turbine industry, i.e. the developing off-shore industry." (Participant 19)
>
> "I would like to have seen more public information. Governmental and formal information will always be biased (...) information from people living close by who are affected by the wind farms (...)" (Participant 15)

Participants 1 and 7 refer to the idea that wind energy should be discussed in the broader context of all possible energy sources. These comments, as well as participant 19's, address the question "where to frame the problem?"[56]. WePWEP focuses on on-shore wind farm siting. Thus, discussing energy choices or addressing offshore wind energy was considered the beyond scope of WePWEP.

Participant 2's comment is very pertinent. The issue raised is not indeed addressed in WePWEP (as it is a testing prototype), but it is relevant. WePWEP and similar systems, when not properly contextualised in the planning process, can raise expectations and, at the end of the process, participants might feel overreached.

Regarding the lack of public opinion (a comment by participant 15), it is an issue that can only be resolved with more people using WePWEP. Other participants have stressed the same point when asked about functionalities they would like to have available in WePWEP (*cf.* Table C.5, Appendix C):

> "Would be good to have more people involved on website. Hopefully that will happen in the future." (Participant 3)
>
> "(...) testimonies from people who live near sites." (Participant 9)

[56] The same issue had been raised during a "loading WePWEP" session (*cf.* section VII.4.2).

Other suggestions are:

> "(...) some degree of photographs of the sites that could be accessed from the map - interactive photos of an area with or without turbines, or with different number of turbines perhaps?" (Participant 6)
>
> "A postcode finder so that residents can see in detail their local area." (Participant 11);
>
> "(...) The maps given are all 2D, perhaps some idea of the topography and visibility of a turbine could be given as a separate layer." (Participant 18)

Participant 11's suggestion would definitely be a good help for locals to the study area to find their way on the map. The other two suggestions are somewhat related. During the development of WePWEP the use of 3D maps/images was considered. The idea was, nevertheless, forsaken based on the argument that it would put an emphasis on the visual and landscape aspects and hence "distort" the decision-making process. Specifically regarding participant 6's suggestion, Bishop and Miller (2007) developed a system similar to what he proposes; their interest was to assess public's visual perception of (off-shore) wind farms, and this is not purpose of WePWEP.

VIII.4.6. Discussion

WePWEP was designed with a specific purpose in mind: create a public participation system that fosters and enhances learning during the very process of participating in spatial planning. Although not involving "real public", the conducted experiment aimed at evaluating WePWEP. Participants' feedback on it has been presented in the previous sections. This section discusses the outcome having in mind that participants in the experiment are not truly representative of members of the public– although they are likely representative of WePWEP' users if it were released online (*cf.* section VIII.2.6).

WePWEP seems to be a learning tool: over 70% of participants in the experiment stated to have learnt while using the system, including half of the participants who acknowledged to be well informed about wind energy during the registration process.

Moreover, it seems that WePWEP fulfills its goal to a large extent. In fact, when explicitly asked to evaluate WePWEP in relation to its goal achievement, over 80% of participants expressed a positive view, with more than 50% indicating high levels of achievement (5 and 6 on a 1-6 scale). Four participants (14%) declared that WePWEP entirely achieved its goal. This positive feedback needs, nevertheless, to be read carefully because WePWEP was generally not found to be a system easy to use. Although dependence between 'WePWEP ease-to-use' and 'WePWEP's goal achievement' was not proved for the participants in the experiment (*cf.*

section VIII.4.2), it could be proved statistically dependent for a different groups of evaluators (e.g. a sample of the general public).

Specifically concerning learning in WePWEP, two remarks seem opportune:

- WeWPEP facilitates different ways of learning: participants in the experiment stated to have learnt by reading information provided, experiencing the difficulties of decision-making within the SDSS and also by exploring contributions by other individuals (social interacting); and
- four participants (15%) re-engaged on a new "experience cycle" after visiting the AM; this reinforces Kelly's assertion that individuals' constructs can be moulded by social interaction (*cf.* section II.2.3). As discussed in section VIII.3.5, the small number of participants that returned to the SDSS after having explored the AM can be symptom of a number of factors, including the restricted knowledge of the study area and the limited time to use the system.

Regarding the WePWEP implementation, three aspects are worth discussion:

- the level of information provided;
- complexity of the system; and
- time needed to complete it.

The first two are naturally related with the latter and this is reflected in the discussion below. With regard to the first aspect, participants in the experiment made the following comments:

> "(...) The information is very detailed and the overall concept of the site, the headings and the organization of how the info is delivered is good, in a logical way. The more you read the info the better you could 'play' with the interactive maps to choose the suitable sites." (Participant 1)
>
> "It was really very detailed; I'd be surprised if people would get through the whole site. (...)" (Participant 10)
>
> "There is a huge array of information on the web-site, this is of course a great thing. It is reasonably easy to access specific information you are trying to find. (...)" (Participant 13)
>
> "This is a great site! It is very in depth and that is excellent, but you have to remember it will be too much for the casual browser, they probably will not give it their time. (...)" (Participant 28)

Clearly, two positions can be identified: for some, the wide range and in-depth information available in WePWEP makes it a "great source of information", for others, it is as a factor to put them off. Astutely, participant 2 alerted:

> "(...) With so much information the risk is information overload which may lead people to answer questions without having really thought them through, thus introducing misleading responses." (Participant 2)

The level of information that needs to be provided in public participation contexts is an interesting topic and, to the best of the author's knowledge, an unaddressed research question. It is common sense that finding the right balance is crucial to maintain participants' interest. However, finding this point is not obvious. For example, the analysis of WePWEP's second tier usage revealed that more information relating to the criteria should be placed on the main pages. But the question is "Where to draw the boundary?". It seems that only by a trial and error process, experimenting with the public, a suitable version can be achieved (webpage design issues also play a role here).

As for the second point, WePWEP's second and third tiers raised several difficulties (*cf.* sections VIII.3.3, VIII.3.4 and VIII.4.4). Significantly, when asked for suggestions for further improvement of WePWEP, various participants answered:

> "I think it has to be made a bit simpler for the 'ordinary' person to be able to use it adequately." and "Simplify!" (Participant 2 and 11, respectively)

> "I found it quite easy to use but I am very confident with computers and the internet. I think others could have difficulty unless there was some kind of walk through to guide them through sections of the site that cause them problems." (Participant 26)

As noted in section VIII.3.5, since common websites do not offer similar functionalities to those available in WePWEP, experiencing such difficulties is natural. Expectations for the future are that more websites will offer comparable functionalities, which will increase the public familiarity with them and, consequently, turn systems similar to WePWEP more attractive from the usability point of view. Meanwhile, in addition to simplifying the system and/or improving the "help" functionalities, the alternative seems to be promoting such systems in settings where a facilitator can provide assistance and/or guide (a group of) participants through the system.

Both, the amount of information available and the complexity of WePWEP require availability from the users to explore and "get the grip" of it. This is an extremely important point when designing public participation systems and it highlights the major discussion points emerging from the analysis of WePWEP usage and feedback:

- amount of information provided *versus* time required to explore it *versus* availability or willingness of the participant to do so; and
- complexity of the system *versus* participant's ability to cope with it *versus* potentiality to engage users.

Regarding the first point, the author's position is reflected in the conception of the first tier: as long as the users are not forced to read all the information and are aware of what comes next, they can move straight on to more engaging activities within the website and are not necessarily put off the system. Moreover, knowing that a repository of information is easily available, users may return to learn more on the topic.

Regarding the second point, the author's position is that usability and perceptibility should be maximised in any system, otherwise many participants will not be able to use it. More often than not, this implies simplifying the system, but some functionality necessarily involves complexity (also due to the enabling technology). The usage of complex systems by laypeople should be promoted in a suitable setting, where assistance/guidance can be provided.

Regarding the time needed to complete WePWEP, some participants in experiment were fairly complacent. They stressed that interested people will make time for it and issues tackled are intrinsically complex:

> "A website that takes a fairly long time to go through isn't really a problem. If the user has an interest (such as proposed site near their home) they will not mind using the time." (Participant 5)

> "Using the site does take some time but that is a reflection of the complexity of the issues." (Participant 18)

Others, as noted, recommended simplifying it. Participant 28 leaves a valuable remark to improve WePWEP:

> "(...) It is very in depth and that is excellent, but you have to remember it will be too much for the casual browser, they probably will not give it their time. I suggest a short, snappy front page to grab the interest of casual browsers. This will also give the '5 minute person' something to think about - and hopefully they might come back."

To conclude, it is worth remarking that some participants' comments do reflect their high level of education (*cf.* section VIII.2.1): not considering themselves regular members of the public (based on their familiarity with computers, the Internet and GIS), after providing personal feedback on WePWEP, they often analysed the system having in mind their conception of "member of the public".

VIII.5. Participants' views on the principles of WePWEP

In addition to specific feedback on WePWEP, participants were consulted on the principles underpinning its development. The aim was to investigate to what extent the ideas conveyed in the literature on wind energy (e.g. Devine-Wright, 2005b; Pasqualetti, 2002; Wolsink, 2007) and on public participation (e.g. Carver *et al.*, 1996; Healey, 1997; Shiffer, 1995) are true/applicable in the context of the current case study,

Questioned whether the public should be involved in decision-making concerning wind farm siting, 25 out of 28 participants responded yes; none answered no, Figure VIII.9.

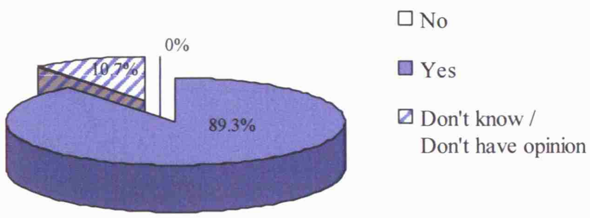


Figure VIII.9 – Participants' views on whether the public should be involved in decision-making regarding wind farm siting.

Justifications by the 'yes' group can be aggregated in four categories (all justifications available in Table C.7, Appendix C):

- because the decision affects them;

  "The local public are stakeholders who have to live with the decisions daily." (Participant 10)

  "Especially who lives near the wind farm or who are going to have wind farm near his or her house." (Participant 24)

- because we live in a democratic society and it is legally required;

  "Public consultation needs to be part of any major planning process. (…)" (Participant 5)

  "Particularly those that live in the local area, or who visit often, it is important in a democratic society that public participation be an important part of the process." (Participant 14)

- because public involvement fosters acceptance of the technology:

  "If people are left out of the decision making process, this WILL have a negative effect on their opinion of wind turbines and this could feed through to other environmental issues." (Participant 6)

  "(…) We have to move towards projects such as wind farms in the future and for them to become widespread, they will have to have public support. It is vital that the public get a say in where they are placed, they will never thrive if they are unpopular." (Participant 28)

- because it is an educational opportunity:

  "(...) Being involved in the decision making process informs and educates and this is as important as anything else." (Participant 16)

  "The public should learn about the limitations for siting wind farms so that they can make more informed decisions with respect to their views on the development of wind power in the UK." (Participant 26)

Nonetheless, some participants expressed some cautious regarding the level of involvement:

> "But not a lot. Is the job of the experts, but feedback is always needed. (...)" (Participant 1)
>
> "(...) however the debate/public inclusion should be on where to site for each given settlement and not whether to site." (Participant 18)
>
> "(...) I think they should have the opportunity to bring up their problems and complaints, or their support, so that the authorities take these into account when deciding whether to allow planning permission. I don't think the public should actually have a say in the final decision though." (Participant 27)

A participant without a formed opinion said:

> "They would just be concerned about seeing one from their house and not thinking about the environment" (Participant 8)

It is curious to note this latter justification implies a depreciatory behaviour on the public. Despite that, the participant did not answer 'no' to the question. This reveals a certain openness of mind, symptomatic of a high level of education. As some of the earlier quotations also reflect knowledge on public participation issues, the statistics presented in this section are likely biased due to the characteristics of respondents (*cf.* section VIII.2.6).

Consulted on the importance of knowledge to participate in decision-making, most participants recognised value on it, Table VIII.19.

		To what extent does better knowledge help people to participate in decision-making process?						
		does not help 1	2	3	4	5	helps a lot 6	Total participants
Participants	No.	--	--	2	2	8	16	28
	%	--	--	7.1%	7.1%	28.6%	57.1%	100.0%

Table VIII.19 – Importance of knowledge to participate in decision-making.

Questioned whether a public participatory system should solely be concerned with collecting views, without seeking to inform, most participants (21 out of 28) disagreed, Figure VIII.10.

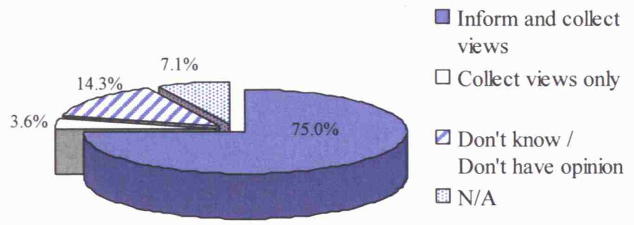


Figure VIII.10 – Participants' opinion on whether a public participation system should be solely concerned with collecting views.

Their justifications stress that adequate, unbiased information is essential for the public to be able to make informed judgements (all justifications available in Table C.9, Appendix C):

> "Issues, such as wind energy, are often surrounded in myth and controversial argument and counter argument. Without adequate, honest, information participants will only be able to express unrational opinions based on unsubstantiated emotional responses to issues." (Participant 18)

> "People are not able to give useful comments and thoughts unless they are given appropriate information, so in the public participation process, reliable unbiased information should be easily available to the public." (Participant 27)

A justification by a participant who stated not to have a formed opinion reads:

> "Yes and no. The thought collection process is different to one that also seeks to inform, so it depends what the ultimate aim is." (Participant 2)

Interestingly, one participant who stated that public participation systems should collect views exclusively thinks that information should be provided in reaction to identified misconceptions and/or information gaps:

> "I think that people should be able to voice their opinion based on their knowledge, and then be given further information for clarity and to educate. (...)." (Participant 16)

This reflects a rather passive and restricted view of public involvement in decision-making.

Typically public participation in wind farm planning occurs with a specific wind farm proposal in mind: when the developer presents their intention to a local community or during the planning application process. WePWEP involves the public in a much earlier stage, when no specific projects are considered. 61% (17 out of 28) believe there is value in involving the public at such an early stage, Figure VIII.11.

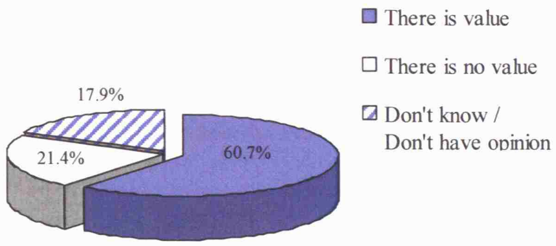


Figure VIII.11 – Participant's opinion on whether there is value in involving the public at planning stages when there is no planning applications to consider.

Participants holding this position stressed the following points:

- it generates win-win solutions:

> "May save developers time in avoiding very controversial sites and may open up new possibilities." (Participant 9)

- contributions are not affected with NIMBYism:

> "Because it helps people formulate their opinions BEFORE nimby'ism comes into play. (…)." (Participant 16)

- it creates a sense of empowerment and ownership of decision-making:

> "The more people feel involved the more they will like the idea, as they will feel their input is valued." (Participant 12)

They also raised two legitimate concerns: costs and (fear of) lack of public adherence:

> "Although, it depends on the cost of involving the public. (…)" (Participant 25)

> "I think it is a good idea but I don't think the majority of the public would bother involving themselves in the planning procedure unless application for planning of a wind farm was happening near them." (Participant 22)

Participants who see no value in such an early involvement justified it saying:

> "Getting people to participate in an exercise like this could raise expectations or demands from the planning process. (…)." (Participant 2)

> "If no location has yet been firmly decided the public cannot make valid feedback." (Participant 4)

> "People become too involved before any suggestions are put forward thus complicating the planning issues." (Participant 11)

It is interesting to note that this last comment diametrically opposes that by participant 9 (i.e. development of win-win solutions).

VIII.5.1. Discussion

WePWEP and, more generally the whole research project, was built upon knowledge in the literature, such as the public should be/wants to be involved in wind farm siting (e.g. Pasqualetti *et al.*, 2002) and public participation systems should look at informing and collecting views (e.g. Carver *et al.* 1996).

To confirm these foundations, or highlight a possible mismatch, participants in the experiment were consulted upon four aspects:

- public involvement in the wind farm siting decision-making process: no participant claimed that the public should not afford this opportunity, although some emphasised that decision should not be delegated on them;
- relevance of knowledge to participate in decision-making: over 90% of participants acknowledged its importance;
- public participation systems should be solely concerned with collecting view, without seeking to inform: only one participant (4%) agreed with this statement; and
- public involvement in strategic planning: the majority of participants (61%) recognised value on it.

The outcome of the three first questions was expectable and confirms what is conveyed in the literature. In contrast, responses to the forth question was slightly surprising because strategic planning is typically perceived as too distant for citizens to be interested in. Costs and lack of adherence, the two concerns raised by participants who see value in involving the public at strategic level reveal that they also predict some public disinterest; nevertheless, aware of the potential benefits, they recognised value on the involvement. This stand reflects some awareness on environmental and planning issues; therefore, it is likely that results obtained, particularly on this last question, are biased by the group of respondents involved: well educated and with a particular interest on environmental matters. Argumentation by some participants, not only on the last question, equally suggests a possible bias.

Overall, participants in the experiment supported the basis of this research. The general public would probably not recognise value in getting involved in the planning process when no specific proposals are in discussion; however this does not affect the outcome of this research because strategic planning is only the selected application (*cf.* section IV.4.1). The proposed conceptual framework is general and consequently applicable to any spatial planning problem, irrespective to the scale.

VIII.6. Participants' contribution to wind farm siting

WePWEP is the research's object of concern. However, it is worth analysing the contributions by the participants to the selected case study. Contributions were sought on three aspects:

- the way the wind farm siting planning problem was structured;
- importance of the evaluation criteria and sub-criteria for decision-making; and
- opinions/arguments regarding wind farm siting (and wind energy in general).

The next sections summarise the participants' input on each of these aspects.

VIII.6.1. Structure of the planning problem

Webpages in the second tier specifically ask participants to comments on the evaluation criteria identified and the methodology used to assess performances of feasible sites on them (*cf.* Figure VI.5 and VI.6). Received contributions can be consulted in Table D.3, Appendix D.

In total twelve contributions were received from nine participants. Comments are rather generic and only a few made their point clear. These mentioned: (1) a perceived overlap between the criteria 'Visual impact' and the 'Impact on landscape' and (2) local impacts should consider job creation.

Regarding the first point, the operationalisation of both criteria was developed in a way to dissociate the two aspects, which although related, LI/IEMA (2002) clearly distinguish them. Regarding job creation, this aspect was not included because at maximum small size wind farms can be installed in the study area and these typically do not create job positions – only temporary work during construction work.

VIII.6.2. Importance of evaluation criteria

Five evaluation criteria were pre-identified for the DM (participant) to weight for decision-making (*cf.* section V.4.1.2.2). Figure VIII.12 depicts the weight that, on average, participants attributed to each criterion. Table VIII.20 provides more detailed information (data at individual level is available in Table D.1, Appendix D).

'Site characteristics' and 'Impact on ecology' were, on average, considered the most important criteria for decision-making in wind farm siting. Respectively, eleven and ten participants selected them as the most important criteria.

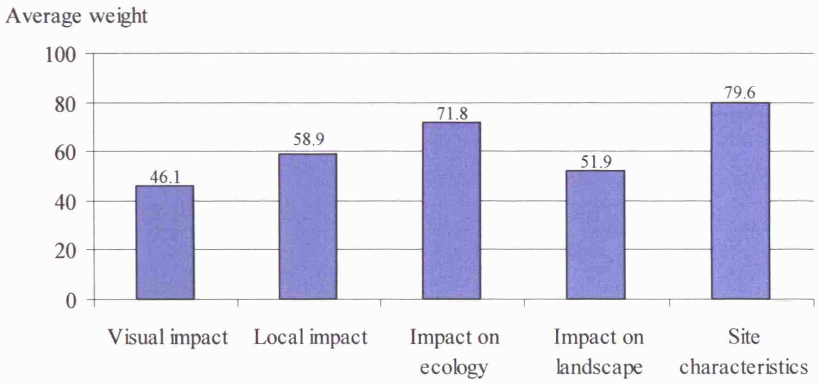


Figure VIII.12 – Average weight of evaluation criteria.

Criteria	weights attributed by participants				No. times selected as the most imp. criterion
	$\bar{w}$	s	max.	min.	
Visual impact	46.1	29.6	100	0	1
Local impact	58.9	24.3	100	15	2
Impact on ecology	71.8	29.2	100	22	10
Impact on landscape	51.9	26.1	100	10	2
Site characteristics	79.6	25.4	100	12	11

Table VIII.20 – Basic statistics on weights of evaluation criteria.

In contrast, 'Visual impact' and 'Impact on landscape' were, on average, given the least importance for decision-making, selected, respectively, only once and twice as the most important criterion. This is a surprising result as it contradicts what is conveyed in the literature, i.e. that landscape and visual impacts are the greatest source of public concern regarding wind energy and the dominant factors in explaining opposition to wind farm projects (*cf.* section IV.2.4). As discussed in section VIII.6.4, this result can be a bias of the participants involved in the experiment, but can also be a consequence of other factors.

Each criterion groups some sub-criteria, which default weights can be reset by participants (*cf.* section V.4.2). Table VIII.21 provides statistical data on reset weights (information at individual level is available in Table D.2, Appendix D). As discussed in section VIII.3.3, the small number of participants who reset default sub-criteria weights (column 'No. participants') is likely due to relatively "hidden" link to the webpages where that was possible and the burden of taking the decision-making process into a such level of detail.

	Sub-criterion	No. participants	Weights μ	σ	Max	Min
Visual impact	Local inhabitants	5	74.4	32.9	100	20
	Road users	5	46.6	29.9	100	12
	Recreational environments	5	62.2	34.8	100	0
	Built heritage	5	45.6	4.6	50	40
	Designated areas	5	62.6	33.0	90	0
Local impact	Noise impact	5	87.6	24.8	100	38
	Shadow flicker effect	5	40.4	25.9	80	10
	Impact on property value	5	55.8	32.6	100	10
Impact on ecology	Birds	1	90.0	0.0	90	90
	Nature conservation designations	1	100.0	0.0	100	100
Impact on landscape	Site remoteness	4	93.3	9.4	100	80
	Cumulative impact	4	80.0	28.3	100	40
	Distance to major roads	4	88.7	10.3	100	75
	Distance to large settlements	4	88.3	10.3	100	75
Site characteristics	Estimated energy output	2	100.0	0.0	100	100
	Size of feasible site	2	22.2	2.0	24	20
	Agricultural value of the site	2	38.0	28.0	66	10
	Size of closest settlement	2	16.5	3.5	20	13

Table VIII.21 – Importance of individual impacts which make up "overall" impacts (criteria).

VIII.6.3. Contributions to discussion forum

Nine participants added a contribution to the discussion forum within AM: six replied to existing contributions and three started a new thread. Threads were created with the titles 'Wind farms at sea'; 'Wind energy' and 'Localising it'. The first questioned why there are not many; the second made two points in favour of wind energy and highlighted that any energy technology has downsides; and the third identified a need for community involvement in wind energy development. The first and the last threads generated, respectively, one and two other contributions; in the last case one supported the stance and the other challenged it to some extent. Curiously, no reply was marked with the type of contribution 'pro' or 'against' – maybe the participants interpreted these types as being in favour and against wind energy and, as it did not apply in their context, chose the 'neutral' type. Furthermore, no contribution has a spatial reference associated, despite one explicit refer to geographic features (*cf.* section VIII.3.4; contributions are available on Table D.4, Appendix D).

The analysis of the discussion forum clear reveals its disadvantages in relation to a true argumentation system (*cf.* section II.4.2): one contribution makes various arguments and a reply does not address all of them; and sometimes makes new points. Moreover, some contributions are relatively long, making them less attractive for the readers. As the debate evolves, and because users tend to read the most recent contributions, relevant points in the discussion will likely get lost or be repeated. Parallel threads may even be started on issues already addressed under other thread. In a longer run, the forum will lose objectivity and participants will have difficulties in grasping the full picture of the debate. WePWEP's discussion forum contains now several relevant points and questions regarding wind energy and wind farm siting. For new initiatives involving WePWEP, it is worth to systematise the current debate in a visual structure to facilitate the apprehension of argumentation and their enchainment. CRANES's strategic argumentation view (Horita, 2000b) and QuestMap^{TM}'s pictograph hyperlinks (Conklin, 1996) are two different ideas to implement this structure.

VIII.6.4. Discussion

Although the goal of the conducted experiment was not collecting views on wind energy or associated topics, participants' input was systematised and an surprising result obtained: 'Visual impact' and 'Impact on landscape' were considered by the participants the least important criteria for decision-making on wind farm siting. This result contradicts the literature and the participants' biggest concerns regarding wind energy (*cf.* Table VIII.7); hence it makes one wonder about a cause for it. Three justifications are plausible. First, a bias from the group of participants in the experiment: recruited in a higher education school of environmental sciences, they might be more "logical" and sensitive to ecological aspects than common citizens, so they selected 'Site characteristics' and 'Impact on ecology' as the most important criteria for deciding on where to site wind farms. The fact that they have little knowledge of, and affinity with, the study area might also have played a role. Participant 16's contribution to the discussion forum is expressive with this regard:

> "Yes, they do look good. I agree 'graceful'. But, I think they detract from landscapes that are otherwise beautiful without them. So, okay they add something in the Black Country... put them near Birmingham but not in the beautiful Welsh mountains. I talk about Wales because I know it but the same goes for the rest of the UK. But, it's windiest in the most beautiful places."

It clearly shows that when there is some affinity with the area, likely impacts on the landscape gain another dimension (although this participant was consistent in her position and selected 'Impact on landscape' as the most important criterion, *cf.* Table D.1, Appendix D).

Second, the fact that some participants perceived an overlapping between the criteria 'Visual impact' and 'Impact on landscape' (participants 5, 16 and 20 expressed it on their feedback); this might have led them to lower the weight given to these criteria on an attempt to balance a possible double weighting. Third, that members of the public, when assuming the position of DM, do act as rational agents as found by Evans *et al.* (2004).

The author acknowledges that some bias might exist, but considers that the third factor was determinant for the 'Site characteristics' criterion to have been selected as the most important to decide on wind farm siting (within this criterion, participants considered the sub-criterion 'Estimated output energy' by far as the most relevant, *cf.* Table D.2, Appendix D). Only a new experiment involving a sample of "real public" (preferably locals to the study area) would provide the necessary data to advance a more definitive justification for this extraordinary result.

The other interesting (although expected) result from the analysis of the participants' input is that discussion forums do become rapidly overwhelming for people interested in learning quickly the arguments in a debate. AM/discussion fora need a "strategic view" (Horita, 2000b) to help participants identify which contributions they want to read. As suggested by Horita (2000a) and Tweed (1998) this has to be created by a discussion moderator; not the users of the discussion forum.

VIII.7. Conclusion and implications

This chapter presents the results of the experiment conducted to evaluate WePWEP. More generally, the proposed conceptual framework itself was in evaluation. Results are presented regarding (1) the participants in the experiment; (2) how they have used WePWEP; (3) their feedback on the prototype; (4) their views on basic principles behind WePWEP's conception; (5) contributions to wind farm siting.

Regarding the first point, the group of participants involved in the experiment was considered to reflect the characteristics of the universe of recruitment, and not the public in general. They had a high level of education and a particular interest on environmental issues; some participants did not identify themselves with common members of the pubic due to their high proficiency on using the Internet and familiarity with the GIS technology. Participants' characteristics naturally influenced the way they perceived and handled WePWEP - this fact was kept in mind when interpreting feedback on the prototype and when inferences to public participation systems in general were made.

The major goal of the experiment was to assess whether WePWEP resulted in an enhancing-learning platform. Feedback from participants was very positive and three different types of learning were acknowledged: (1) from reading objective information; (2) experiential, within the second tier; and (3) from learning views from other participants. Furthermore, the hypothesised synergies arising from linking an SDSS and an AM were confirmed: four participants did return to the SDSS to revise a submitted planning proposal after having inspected contributions by other participants in the AM. These results are encouraging regarding the proposed conceptual framework.

Difficulties were, nevertheless, observed while participants used WePWEP and they acknowledged them. Table VIII.22 summarises the difficulties experienced by the participants and their recommendations for prototype improvement, and Table VIII.23 compiles their ideas for further development.

WePWEP	Difficulties experienced	Recommendations for improvement
1st tier		- make text more concise - avoid uncommon vocabulary - remove the 'Back' and 'Next' navigation buttons
2nd tier	- understanding weighting procedure - understanding the map layers overlapping - grasping the difference between 'Visual impact' and 'Impact on landscape'	- provide an overview of the whole process at depart - simplify the TOC/legend - make access to 'Weighting sub-criteria' webpages clearer - provide handy instructions on how to use the maps
3rd tier	- understanding the map layers overlapping - understanding the purpose of the tools provided - extending compressed threads of the discussion forum	- provide handier instructions on how to use functionalities available

Table VIII.22 – Difficulties experienced by the participants while using WePWEP and their recommendations for improvement.

Ideas for WePWEP further development
- have a postcode finder nearby the map
- have some degree of photographs of the sites that can be accessed from the map
- map layers providing an idea of the topography and visibility wind turbines
- have a moderator to explain features and guide users over the system
- if used in a real-word situation, make clear the WePWEP contribution to the planning process

Table VIII.23 – Ideas for WePWEP further development.

From the analysis of WePWEP usage and received feedback, a few lessons were drawn:

- usability is a very important aspect: offering functionalities that are not intuitive for the users makes them irrelevant and, potentially, using the system a frustrating experience. Thus, if the system is realised too complex for the targeted audience, it is preferable to encourage its use during organised events, when assistance/guidance can be provided;

- users are critical with regard to information provided: if they perceive information inadequately subjective they will not read it; therefore making references explicit seems important. Not all users will access/read them, but some may inspect who is the resource's author to evaluate its credibility;
- familiar users with the Internet appreciate flexibility in navigation: the 'Back' and 'Next' page buttons can be perceived as too oppressive in information areas, as users might feel obliged to read all information;
- texts should be concise and relevant information for understanding the system (or processes within the system) should be provided in main pages;
- users prefer localised assistance, for instance, via pop-up boxes suggesting ways of proceeding rather than help files where they have to find out the needed piece of information; and
- users will use the system if they have an interest on it; in this case, it is likely that they will take the required time to complete it.

These lessons are not specific to the implemented system, and can generally be used to inform the design of web-based public participation systems.

Finally, two interesting results came out of participants' contributions:

- there is value in involving the public in the strategic planning of wind farms location;
- visual and landscape impacts are the least important criteria from the set of five pre-defined criteria; whereas 'Site characteristics' (potential energy output) is the most important.

While these results may be biased by the group of individuals that took part in the experiment, the first point may suggest a change of mentalities due to greater availability of information on environmental and planning issues. The latter may confirm that, when in the position of the DM, individuals make informed choices based on data presented to them.

To investigate the bias possibility, experiments involving participants representative of public need to be conducted. The other two points call for the development of systems similar to WePWEP to make available more information, instigate learning and facilitate informed contributions to decision-making. These will contribute to (1) citizens' enlightenment with regard to their social and environmental surroundings and (2) ownership of decision-making.

Chapter IX

Conclusions and further research

The aim of this thesis is to investigate whether a proposed conceptual framework integrating an SDSS and an AM results in a fostering, learning-enhancing system for public participation in spatial and environmental planning. A prototype implementing the proposed framework was built and subsequently tested. Before turning to overall evaluations and general conclusions it seems appropriate to provide a review of the arguments developed, and work described, in the various chapters. This chapter ends with suggestions for further research.

IX.1. Summary of the research and its findings

The starting point of this research was two-fold: a recognition that stakeholders (including laypeople) are typically not aware of all the issues involved in the planning process and, sometimes, are misinformed regarding certain aspects; and the evidence that stakeholders do not often know their own preferences for decision-making (e.g. Densham, 1990). This suggested that participatory systems should foster and enhance learning during the very process of participation.

The drive for the thesis is made clear in Chapter I: the design of learning enhancing systems needs to be informed by a learning theory. This is an innovative idea, *per se*, as participatory systems have been conceived to tackle specific problems, such as inadequate access to data and the tools that allow informed decisions (e.g. Carver *et al.*, 1996; Shiffer, 1995) or lack of a platform supporting geo-referenced discussions (e.g. Rinner, 1999), and have overlooked learning as a core concept for these systems' designs.

Hamilton *et al.* (2001) suggest that, when the planning process is understood as a learning system, a useful learning theory to consider is Kelly's PCT (1955). This theory proposes that learning has two components: an individual one, corresponding to making sense of our individual experiences and tacit knowledge, and a social one, corresponding to the "acquisition" of other individuals' construct systems when we play a social role. In Chapter II the full body of PCT is expounded and two different types of planning support systems introduced: SDSSs and AS. The former are argued to facilitate the individual component of learning, since they offer a flexible environment where individuals can explore the decision problem and crystallise their own preferences with regard to decision-making. The latter are asserted to promote the social component of learning as they enable individuals to access others' rationale and support social interaction. By integrating these three realms, a conceptual design for learning-enhancing participatory systems is proposed: it includes an information area, an SDSS and an AM, a special instance of an AS (*cf.* Figure II.). This is the first time that an explicit integration of an SDSS and an AM is proposed, so this integration forms the basis of the main research question: how to integrate these two types of systems to achieve a learning-enhancing platform for participation in spatial planning. Chapter II also introduced the context selected for the backdrop of this research: web-based public participation in spatial and environmental planning.

Chapter III developed the proposed conceptual framework aiming at a prototype implementation. For each module, envisaged user-system interactions (i.e. use cases) were described to capture functional requirements. The most relevant functional requirements identified were:

- intuitive, consistent and flexible navigation within and amongst the system's modules: information area, SDSS and AM;
- collect users' input regarding the evaluation criteria for decision-making and generate a planning solution based on them; the user must be able to revise submitted input and generate new planning solutions;
- users must be able to contribute to debates in the AM by adding discussion contributions which may explicitly refer to spatial entities; tools need to be provided to select spatial features from the map and create new spatial features to associate to written contribution;
- generate a "social planning solution" by combining all submitted planning solutions so far and display it on the AM's map viewer; users must be able to explore this solution;
- users must be able to revise a submitted planning solution after visiting the AM, i.e. after gaining awareness of others' concerns and arguments and having inspected the "social planning solution".

Figure IX.1 systematises the conceived web-based public participation system.

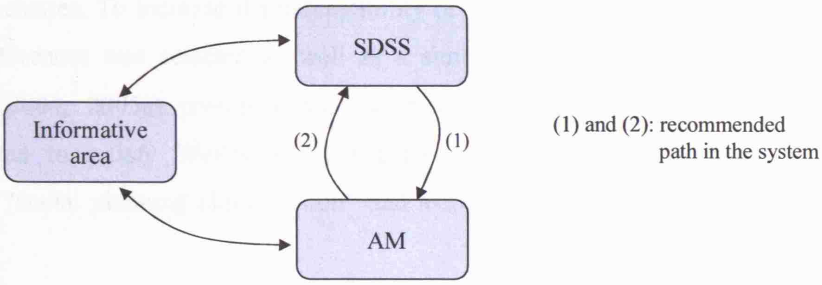


Figure IX.1 – Overview of the functional integration of an SDSS and an AM.

In addition to functional requirements, Chapter III also addressed requirements at other levels such as user-interface, workflow, computer platform, security and unity of the final system.

Chapter IV presented the case study topic and area. The selected spatial planning problem is framed within the controversial topic of wind energy development and consists of engaging the public in identifying suitable areas to site wind farms. This approach to public participation in wind energy planning contrasts to current practices in the domain, which involve the public either at the abstract level of policy-making or when the location of wind farms have already been decided. The advantages of the selected approach are: (1) comparing to abstract level of policy-making, the public is involved in an applied problem solving situation, which is likely to be more engaging; (2) there is no wind farms proposal at stake, so NIMBYism (or unfairness of decision-making (Wolsink, 2007)) will not play a role in the participants' contribution, or it will be reflected as NIABYism, as the same decision rationale is equally applied everywhere; (3) makes it possible to come up with win-win solutions, because developers are directed to areas where they are most likely to have their project approved; and (4) it promotes ownership of decision-making. The case study area is located in the county of Norfolk, East of England, and comprises part of King's Lynn and West Norfolk Borough Council and Breckland District Council. Significantly, the selection of the study followed a rational, three-step procedure. In this process, the search area was reduced at each stage. The final location resulted from a multi-criteria analysis.

Chapter V brought together Chapters III and IV. It put forth a structure and developed the logical design for a prototype implementing the proposed conceptual framework and addressing the selected case study. The prototype was called WePWEP, standing for Web-based Participatory Wind Energy Planning. The information area was designed to provide information on wind energy, discuss relevant aspects of wind farm siting, including the planning application process, and introduce local wind farm projects. The SDSS was developed in line with the existing OSDM (Carver *et al.*, 1996; 2002), after formulating the selected planning problem as a sorting problem. Fundamentally, it asks the DM to weight a set of evaluation criteria and, based on that, classifies previously identified feasible sites to accommodate a wind farm into suitability classes. To increase the perceptibility of WePWEP, a simplified method to elicit the DM's preferences was selected as well as a simple sorting decision rule. As for the AM, Keβler's (2004, 2005a) prototype was adopted as a basis of work. Modifications were implemented to satisfy WePWEP's particular requirements, for example, to display the generated "social planning classification" and associated controversy layer on the AM's map viewer.

Chapter VI focused on the implementation of WePWEP. Technologically, the achieved implementation is quite complex: on the server-side, it involves three server computers and several software packages including ArcIMS, ArcGIS Server, ArcSDE and Oracle; on the client side, it is a "thick client" as it requires browsers to be equipped with a Java plug-in (Java VM) to receive and process Java Applets. As discussed, the achieved implementation is not the ideal and there is room for improvement both on the client and server sides. It is worth stressing that the prototype was implemented to be adaptable to other spatial and environmental planning problems and improved/modified with regard to its underlying logic (e.g. sorting decision rule).

The initial WePWEP version was submitted to various tests (alpha, beta and pilot tests) and successive improvements. Chapter VII reported on this process. In addition to improve WePWEP usability and highlight possible bugs, the pilot test had two other goals: test the design for the experiment to formally evaluate WePWEP and populate AM's "social planning solution" and discussion forum. This latter goal was shared by the WePWEP "loading" stage, where true stakeholders in wind energy development were invited to use WePWEP and clarify their position regarding wind farm siting and their concerns. The intent behind this phase was to make the AM a learning platform.

The WePWEP evaluation experiment was described at the end of Chapter VII. It took place at the UEA and participants were recruited amongst staff and students (post- and undergraduate) of the School of Environmental Sciences. Participants' usage of WePWEP were observed and recorded and they were asked to provide feedback on their experience with the prototype. Results from the experiment were presented and discussed in Chapter VIII. Below is a summary of the participants' feedback:

- WePWEP was found a good learning resource: over 70% of participants stated to have learnt while using the system; the information area was acknowledged as the system's module (tier) that has contributed the most to learning, followed by the SDSS and the AM;

- WePWEP was recognised as a fostering and learning-enhancing tool: more that 80% of participants were positive in relation to its goal achievement, 17% of which stated that WePWEP fully achieved its goal;
- WePWEP's second and third tiers were found relatively difficult to use: difficulties were reported on understanding the map interface in relation to the associated TOC/legend (which was designed upon GIS principles), carrying out the decision-making process and exploring contributions in the AM; and
- WePWEP was found to take rather long to complete, a perception linked to the perceived ease-to-use of the system.

Regarding WePWEP's usage, the following were observed:

- participants spent approximately the same time in the information area and SDSS, and slightly less in the AM – this can be an effect of the looming end of the session;
- participants were pro-active while using WePWEP: in addition to reading information provided in the first tier, they looked up references and accessed external resources from the 'Learn more' sections;
- most participants did not look up detail explanation on the concepts involved in the SDSS or assistance on how to use the AM;
- almost all participants re-stated their preferences for planning decision-making after examination of the consequences of their initially expressed preferences in terms of the planning proposal;
- participants did not make use of the most advanced functionalities enabled by the AM (e.g. search the discussion forum by keywords or create a spatial reference) – in some cases this was partly due to lack of time to explore the tools available;
- 21% of participants returned to the SDSS after having explored other people's contributions and the "social planning proposal" on the AM; the same percentage acknowledged some influence of the others' views upon the development of their own position: the "social planning proposal" was found an interesting feature of WePWEP, but from the participant's feedback, written contributions seemed to have played a greater role in influencing participants' views.

Results from the conducted experiment were evaluated in light of the characteristics of the participants and some lessons were compiled which may be helpful for guiding the design of public participation systems in general.

Figure IX.2 summarises the achievements and contributions of this work.

Chapter II

Literature review and proposal of an innovative conceptual design for a web-based public participation system

Contributions

1. Theoretical framework to develop learning-enhancing participatory systems/initiatives
2. Design for a participatory system integrating a SDSS and an AM.

Chapter III

Specification of requirements of the proposed conceptual framework having in mind a prototype implementation

Contributions

1. Specification of functional requirements (amongst others), for a web-based implementation of the proposed participatory system's design for laypeople.
2. Plan to integrate an SDSS and a AM through (1) "social planning solution" and (2) opportunity to revise a developed planning proposal after "social interaction " within the AM.

Chapter IV

Introduction to the selected spatial planning problem and selection of the case study area

Contributions

1. Public involvement in the strategic planning of wind farms location
2. Rational, stepwise procedure to select a case study area

Chapter V

Development of a logical design for the prototype to implement and structuring of the selected case study problem

Contributions

1. Formulation of the strategic planning of wind farms location as a sorting problem
2. Set of decision criteria for classifying feasible sites for wind farms in suitability classes
3. Indexes for impact estimation on the decision criteria set

Chapter VI

Description of prototype implementation: technical details and final product

Contributions

1. Compilation in a sole resource information about wind energy projects in the study area, approved and not approved
2. Development of a SDSS using ArcGIS Server, the most recent technology by ESRI®
3. Application of an existing AM prototype to a different case study and its integration in a more comprehensive framework for public participation

Chapter VII

Overview of the testing, loading and evaluation phases of the implemented prototype

Contributions

1. Application of the software development techniques:
   - test-improvement cycle;
   - evolutionary prototyping approach

Chapter VIII

Presentation and discussion of results from the prototype evaluation

Contributions

1. Results from WePWEP evaluation were encouraging with respect to enhancing learning and facilitating informed contributions
2. Few guiding directives for designing public participation systems.

Figure IX.2 – Overview of the scientific contributions from this thesis.

The next section makes an evaluation of the experimental results in light of the main research question set in Chapter I.

IX.2. Research questions in perspective

In Chapter I, the main research question reads:

How to build a web-based system combining an SDSS and an AM that serves public participation in spatial and environmental planning?

As noted there, this question implies many sub-questions, both at theoretical and technical level. Answers to these sub-questions were briefly pointed out in the previous section. Now, these answers are put into perspective to conclude to what extent the research question has been answered:

- integrating an information area with an SDSS and an AM is a suitable solution as participants in the experiment acknowledged it to result in a valuable learning resource;
- structuring the three modules as different tiers of an integrated system is technically feasible over the Internet using hyperlinks;
- the proposed sequence between tiers: first, reading background information; second, developing a planning proposal in the SDSS; third, learning about the opinions of other people in the AM; and fourth, if needed, return to the SDSS to revise their initial proposal, seemed to have contributed to the development (and capture) of informed contributions by the participants - some participants expressed that the background information was useful to understand issues addressed within the SDSS; and others felt the need to revise their initial planning proposal after having learnt other people's positions on the problem;
- the selected decision rule did not evoke any comment by the participants and only a couple of participants referred to difficulties in understanding the chosen technique to elicit weights on the evaluation criteria; this is understood as a supporting sign towards the option for simple techniques that meet the purpose;
- difficulties experienced by participants both in the SDSS and the AM (*cf.* section VIII.4.4) revealed that there is room for improvement with regard to the choices made at implementation level; and
- finally, contributions from stakeholders were easy to process since they were stored in a database - this is an important point in public participation systems since input by many participants need to be converted in a suitable format to pass onto the final DM(s) in the planning process.

In consideration to this evidence, it can be concluded that, from the design point of view, the choices made provide satisfactory responses to the main research question. From the implementation point of view, the developed prototype showed a few problems regarding usability and, to a less extent, perceptibility. Therefore, the choices made at this level can be improved. Section VI.11 discussed aspects for improvement at a technical level. At usability/perceptibility level, several improvement points were identified in section VIII.7 (*cf.* Tables VIII.22 and VIII.23).

One needs to be conscious though that the answer to the research question derived here results from only one implementation of the proposed conceptual framework, which was evaluated by only one group of individuals. A more definitive and robust response requires investigation and testing of alternative designs.

IX.3. Methodological conclusions

The research yields some observations about methods that were applied. First and foremost, the research demonstrated that software prototyping is an adequate procedure to investigate the feasibility and usefulness of an application/system. Moreover, it showed that prototyping plays a crucial role in software development. Indeed, by testing and evaluating a prototype, aspects and functionalities that create difficulties or confusion to the end-users can be detected, and subsequently improved (or refined) to achieve a more robust and versatile system. Involving true end-users, i.e. members of the system's intended audience, in the evaluation stage is an important point as often (as it was the case in this research) their report on difficulties experienced that someone with an understanding of the issues behind the system would not expect. Some of their difficulties also provide clues about information that should be made clearer or more visible to facilitate the system's perceptiveness/usability. In the context of participatory GIS, Voss *et al.* (2004) also describe how they have use the evolutionary prototyping approach to identify new requirements for their system in order to make it more robust and widely applicable.

The work conducted also proved that studying existing systems is highly beneficial. On the one hand, they are inspirational resources and, by provoke critical thought, stimulate innovative ideas. In this research, the OSDM created by Carver *et al.* (1996) played that role: positive aspects were mimicked; while aspects considered less complete in the original, or more easily achievable given today's technology, were improved (e.g. use of dynamic maps). On the other hand, they can be re-used and integrated in a new product. With regard to re-using existing code, it should be made clear that this decision requires careful thought as, while it may reduce programming efforts, it is likely to raise other challenges and problems. For instance, it can constrain the deployment environment (e.g. programming languages); require extra computing resources (e.g. computer servers) to deal with old and new technology incompatibilities; or oblige the developer to revise the code to enable the integration (in this project, Keβler's (2004) code had to be modified to receive the reference of the open participant's session and use it throughout). Moreover, if new functionalities are required, it may be necessary to learn a significant part of the existing code and its structure, which, depending on the quality and re-usability of the original code, can be a huge task. Finally, existing prototypes do not typically use the latest technology due to deployment and dissemination time. This may mean that potential benefits of new technologies may be "wasted" when opting for incorporating existing systems.

Finally, for software evaluation, the combined use of (1) carefully designed registration and feedback questionnaires, which went through comprehensive testing; (2) a validated mechanism for tracking users' movements within the system; and (3) software to capture the full interactivity user-system proved to be a successful approach. Indeed, the cross-analysis of users' profile and feedback with their actual usage of the system helps gaining a contextual understanding of their perception of the system and conclude on, or extrapolate justifications for, their feedback. For example, participant 20, who perceived an overlap between the evaluation criteria 'Visual impact' and 'Impact on landscape', did not seek information on how these criteria were operationalised. Significantly, this suggests that this type of information should be made more apparent to the end user, rather than requiring a fundamental revision of these criteria.

IX.4. Conceptual conclusions

At a conceptual level, two main conclusions emerged from the research. First, Kelly's vision of learning (1955) offers an adequate framework to guide the design of participatory systems and, more generally, any participatory initiative. In this research, a web-based integration of an SDSS and an AM, complemented with an information area, was found capable of fostering informed contributions to spatial and environmental planning. In a different setting, combining procedures that stimulate the two learning dimensions proposed by Kelly (1955) will also likely to result in a learning-enhancing participatory environment. In a face-to-face setting, a possible design is by promoting the use of an SDSS (or other planning support tool(s) that instigate(s) the making sense of personal experiences) and open discussion sessions. In contrast to the approach proposed in this thesis, this design requires the physical presence of the contributors to this particular spatial planning in a certain place at a certain time. Nevertheless, both approaches are innovative applications of Kelly's PCT to spatial planning, which so far has been limited to the use of the RepGrid technique to elicit individuals' construct systems with regard to alternative planning proposals (*cf.* section II.2.4).

Second, for a system to be suitable for public participation over the Internet, it must be easily understandable and user friendly. If it cannot meet these standards, participants may provide unwanted or wrongful contributions or forsake the system with a feeling of frustration.

Moreover, participants will need to have an interest on the process or the outcome of their participation to use the system as it requires time and commitment. In terms of an SDSS component design, these aspects have two direct implications: (1) simple, easy-to-understand techniques for preference elicitation and decision-making need to be employed; consequently, for applications in the context of public participation, the SDSS's model base (*cf.* Figure II.3) need not to be populated with several decision rules, for example, as suggested in the SDSS literature for applications in different contexts (e.g. Hobbs *et al.*, 1992; Simão, 2000); moreover embedding into the SDSS the concept of fuzziness (e.g. in the attributes or evaluation criteria as suggested in section II.3.2.3) would make it unduly complicated; (2) iterative preference elicitation as proposed by Densham (1990), Bana e Costa and Oliveira (2002) and Dias *et al.* (2002) is not adequate either for a web-based SDSS, where a facilitator is not present to "seize" the participant and make the discovering of preferences an interesting personal research process. In terms of an AM component design, the above aspects enable to conclude that flexible and ubiquitous structures are preferable for debate organisation and presentation. However, to keep the debate interesting and to foster learning, from time to time, a moderator needs to systematise the arguments in a more concise structure that facilitates their apprehension.

IX.5. Further research

This research explored the integration of an SDSS and an AM to create a valuable framework for public participation in spatial and environmental planning. Instead of exhausting the topic, it opened up new avenues for investigation. Two directions can be suggested: improve the current WePWEP implementation and further evaluate it.

Within the first direction, three ways are possible: (1) pushing the system forward based on the recommendations/suggestions provided by participants in the WePWEP evaluation experiment (*cf.* section VIII.7); (2) experiment new designs; and (3) re-build WePWEP using new technologies. A few ideas for re-designing WePWEP are:

- create different levels of engagement, for example, one for the "hasty user", another for people with greater availability to read provided information and explore the system;
- show in each criterion page the default weights of the sub-criteria involved in estimating performances on it, so participants who disagree with default weights will be able to revise them;
- search for a better balance between the information provided and interest/learning-enhancing capabilities of the system;

- search for a better balance between functionality offered and friendliness of the user interface: this involves testing alternative user interfaces for a same functionality; and
- tighten the SDSS and AM integration (and also the information area).

An example where a tighter integration between the SDSS and the AM would come handy is when, while exploring the decision problem in the SDSS, the user is interested in learning what other users have thought of the way the problem has been formulated. If each SDSS webpage had incorporated a discussion forum, an exchange of ideas would be possible. The more comprehensive AM of the third tier could then include as discussion threads the topic-focused debate of the SDSS pages. Conceptually possible, implementation of this idea will require addressing issues at both technical and usability levels.

With regard to technology, WePWEP can be improved on various fronts (see also discussion in section VI.11):

- by removing all Applets, which take time to download (though only significantly in the AM) and, worse, require the clients to have a Java enabled browser - today there exist AM prototypes that do not require plug-in installation (e.g. Tang, 2006). Opting for one of these may however imply some technological adjustments (e.g. Tang's prototype is developed using PHP while WePWEP uses Java-based technology);
- embedding Google Maps in WePWEP, with three main advantages: (1) gains in terms of usability as Google Maps is a widely used web-mapping service; (2) map copyrights would not be a problem any longer as they are already accessible in the Internet; (3) no resources would be spent in updating maps as they are supplied by a third-party - recently some work has been conducted in taking advantage of Google Maps to publish geographical information in the Internet, so some tools already exist that would make this enterprise easier (e.g. Google Map Creator by CASA);
- by avoiding the use of ArcGIS Server software because (1) it is expensive and planning authorities (potential promoters of the developed system) typically have budget constraints; and (2) since it is a recent software, its development community is still relatively small; therefore planning authorities could face problems in setting up WePWEP and/or adapt it to other spatial planning applications.

If ArcGIS Server is to be replaced, there are two attractive research paths: (1) opt exclusively (or mainly) for open-source or freeware software[57]; and (2) re-implement WePWEP as a service

[57] The difference between open-source and freeware software is that the source code is not made available for the latter.

that can be provided by third-party, albeit at a cost for the researchers. For planning authorities this has the advantage of passing on responsibilities of server maintenance, software licensing, etc.

If ArcGIS Server is kept, there is still room for improvement. A drawback of using ArcGIS Server is each action on the map (e.g. zooming in) requires the whole webpage to be refreshed - this takes time and disrupts the user-system interaction. AJAX technology can overcome this drawback. By enabling the exchange of data with the server behind scenes, the whole webpage does not have to be reloaded each time the user requests a change; therefore, pages feel more responsive. The integration of AJAX and ArcGIS Server is currently a hot topic within the ArcGIS Server development community.

The second direction of research is motivated by the fact that WePWEP was evaluated exclusively based on feedback on the system, with no term of reference (i.e. a control system), and evaluation was conducted under particular circumstances: evaluators were recruited from a special universe, were unfamiliar with the study area and agreed to use WePWEP for approximately one hour. To gain a more robust perspective on how much WePWEP (and, more generally, the proposed conceptual framework) fosters and enhances learning, more extensive evaluation is necessary. Two different approaches seem opportune:

- involve the same group of individuals (or similar groups) in evaluating WePWEP and another control system (such as a single SDSS, a single AM, or any of these integrated with an information area) and gauge their opinions on personal gains (i.e. learning) and comfortableness using the systems;
- spot an adequate context (e.g. during development of supplementary planning documents, public discussion of regional spatial strategies or a controversial wind farm project) and promote the use of WePWEP in real-world circumstances.

In addition, or as an alternative, an equivalent system to WePWEP can be developed to tackle a different planning problem, such as location of new residential areas, and evaluated. These experiments would enable a more final statement regarding the real value of WePWEP and the underlying conceptual framework for public participation in spatial and environmental planning.

IX.6. Final thoughts

Before concluding this thesis it seems opportune to highlight that, in addition to the main contribution of this thesis on the integration of an SDSS and an AM, contributions were also made to the disciplines of wind energy and participatory/electronic democracy.

Within the discipline of wind energy, WePWEP enables public bodies to involve the general public and stakeholders in early stages of the planning processes to identify suitable sites for wind farms location. This represents a refreshing approach to the wind farm siting problem inasmuch as it is generally addressed by wind energy developers in exclusivity; stakeholders and local communities are typically involved only to discuss arrangement details at the local scale, after the location decision has already been made, or during the formal consultation phase required by the planning process (*cf.* section IV.3.4; Lange and Hehl-Lange, 2005; Stock and Bishop, 2005). The advantages of the proposed approach is to permit developers to be guided towards sites where they have greater chances to see their plans approved and local communities to perceive greater fairness in the decision-making process. As a consequence, acceptance rates of wind farm proposals will likely improve and the governments will be able to meet their aspirations with regard to wind (renewable) electricity production.

WePWEP makes use of ICT, and particularly the Internet, to create a more engaging and accessible setting for all interested parties to participate in the shaping of their environment than traditional methods of participation enable (*cf.* section II.6.4). From this point of view, this research contributes to the participatory/electronic democracy discipline and can be put side by side with developments by Carver *et al.* (1996; 2002b), Craig *et al.* (2002), Geldermann and Rentz (2003), Hudson-Smith *et al.* (2002; 2003), Kingston *et al.* (2000), Shiffer (1995), amongst others, who were driven by the purpose of giving the public a greater degree of engagement in planning issues and access to the relevant tools, data and information to enable more informed participation and decision-making.

Finally, it is worth noting the crucial role that computers have played in this thesis, not just because ICT were chosen as the means to reach the public but also to support geographic analyses, impacts modelling (*cf.* sections IV.5.4.3 and V.1) and statistical analysis (Chapter VIII). About 25 years ago, when Jerry Dobson first raised the discussion about "automated geography" (Dobson, 1983), he predicted a substantial impact of computers upon geographic research. Today, this impact is obvious in areas of geography requiring spatial representation and spatial data manipulation, greatly due to GIS. Nevertheless, education has been slow in preparing researcher with skills in both geography and computer sciences. Consequently, until a new generation of researchers is formed with solid background in both disciplines (some universities are already offering programmes to prepare students for this challenge), geographers are forced to dedicate a significant part of their time to learn and handle computer sciences issues – as it was the case to complete this research.

References

AIS (2001) - *Dito - deliberate and decide*, Fraunhofer Institute for Autonomous Intelligent Systems [Online: http://zeno8.ais.fraunhofer.de/zeno/].

Al-Kodmany, K. (1999a) - Visualization Tools and Public Participation: from Crayons to Computers, *Critical Planning Journal*, 6(1), pp. 27-35.

Al-Kodmany, K. (1999b) - Using GIS and Web-Based Technologies in Participatory Planning: Advancing Kevin Lynch's and Jack Naser's Work on a Public Evaluative Image of the City, *Proceedings of the 6th International Conference Computers in Urban Planning and Urban Management*, September 21-24, CD-ROM, 16 pages.

Al-Kodmany, K. (2001) - Bridging the gap between technical and local knowledge: tools for promoting community-based planning and design, *Journal of Architectural and Planning Research*, 18(2), pp. 110-30.

Allmendinger, P. and Tewdwr-Jones, M. (2002) - The Communicative Turn in Urban Planning: Unravelling Paradigmatic, Imperialistic and Moralistic Dimensions, *Space and Polity*, 6(1), pp. 5-24.

Andrienko, G. and Andrienko, N. (1999) - Interactive maps for visual data exploration, *International Journal Geographical Information Science*, 13(4), pp. 355-74.

Andrienko, G., Andrienko, N. and Jankowski, P. (2003) - Building spatial decision support tools for individuals and groups, *Journal of Decision Systems*, 12, pp. 193-208.

Andrienko, N. and Andrienko, G. (2001) - Intelligent Support for Geographic Data Analysis and Decision Making in the Web, *Journal of Geographic Information and Decision Analysis*, 5(2), pp. 115-28.

Antweiler, C. (2000) - Urban Knowledge for a Citizen Science - Experiences with Data Collection in Eastern Indonesia, *Proceedings of ASA Conference 2000 'Participating in Development'*, April 2-5, London, UK [Online: http://www.asa2000.anthropology.ac.uk/antweiler/antweiler.html].

Armstrong, M. P., Densham, P. and Rushton, G. (1986) - *Architecture for a microcomputer based spatial decision support system*, Second Int. Symposium on Spatial Data Handling, Williamsville, NY: IGU Commission on Geographical Data Sensing and Processing, pp. 120-31.

Armstrong, M. P. (1993) - Perspectives on the Development of Group Decision Support Systems for Locational Problem-Solving, *Geographical Systems*, 1(1), pp. 69-82.

Armstrong, M. P. (1994) - Requirements for the Development of GIS-based Group Decision Support Systems, *Journal of the American Society of Information Science*, 45, pp. 669-77.

Armstrong, M. P. and Densham, P. (1990) - Database Organization Strategies for Spatial Decision Support Systems, *International Journal of Geographical Information Systems*, 4(1), pp. 3-20.

Armstrong, M. P., Densham, P. and Rushton, G. (1986) - Architecture for a microcomputer based spatial decision support system, *Second Int. Symposium on Spatial Data Handling*, Williamsville, NY: IGU Commission on Geographical Data Sensing and Processing, pp. 120-31.

Arnstein, S. R. (1969) - A Ladder of Citizen Participation, *Journal of the American Institute of Planners*, 35(4), pp. 216-24.

Ascough II, J. C., Rector, H. D., Hoag, D. L., McMaster, G. S., Vanderberg, B. C., Shaffer, M. J., Weltz, M. A. and Ahjua, L. R. (2002) - Multi-criteria Spatial Decision Support Systems: Overview, Applications, and Future Research Directions, *Integrated Assessment and Decision Support, Proceedings of the First Biennial Meeting of the International Environmental Modelling and Software Society (iEMSs)*, 24-27 June, Lugano, Switzerland, A. E. Rizzoli and A. J. Jakeman (eds.), vol. 3, pp. 175-80 [Online: http://www.iemss.org/iemss2002/proceedings/pdf/volume%20tre/290_ascough%202.pdf].

Baban, S. M. J. and Parry, T. (2001) - Developing and applying a GIS-assisted approach to locating wind farms in the UK, *Renewable Energy*, 24(1), pp. 59-71.

Bana e Costa, C. A. and Oliveira, R. C. (2002) - Assigning priorities for maintenance, repair and refurbishment in managing a municipal housing stock, *European Journal of Operational Research*, 138(2), pp. 380-91.

Bana e Costa, C. A. and Vansnick, J.-C. (1994) - MACBETH: an interactive path towards the construction of cardinal' value functions, *International Transactions in Operational Research*, 1(4), pp. 489-500.

Bannister, D. and Fransella, F. (1986) - *Inquiring man: the psychology of personal constructs*, 3rd edn, Biddles Ltd., Great Britain.

Barron, F. H. and Barrett, B. E. (1996) - Decision Quality Using Ranked Attribute Weights, *Management Science*, 42(11), pp. 1515-23.

Batty, M., Chapman, D., Evans, S., Haklay, M., Kueppers, S., Shiode, N., Smith, A. and Torrens, P. (2001) - Visualizing the city: communicating urban design to planners and decision-makers, in *Planning Support Systems: Integrating geographical information systems, models, and visualization tools*, R. Brail and R. Klosterman (eds.), ESRI Press, Redlands, California, USA, pp. 405-43.

Batty, M. and Densham, P. J. (1996) - *Decision support, GIS, and urban planning* [Online: http://www.geog.ucl.ac.uk/~pdensham/sdss/s_t_paper.html].

Beddoe, M. and Chamberlin, A. (2003) - Avoiding Confrontation: Securing Planning Permission for On-Shore Wind Energy Developments in England: Comments from a Wind Energy Developer, Planning Practice and Research, 18(1), pp. 3-17.

Beilin, R. I. (2001) - The Farmer's View: How Seeing the Local Landscape Defines On-Farm Conservation, in *Sustaining the Global Farm - Selected papers from the 10th Int. Soil Conservation Organization Meeting*, R. H. Stott and G. C. Steinhardt (eds.), Purdue University and the USDA-ARS National Soil Erosion Research Laboratory, pp. 147-51.

Belacel, N. (2000) - Multicriteria assignment method PROAFTN: Methodology and medical application, *European Journal of Operational Research*, 125(1), pp. 175-83.

Belacel, N., Wang, Q. and Richard, R. (2005) - Web-integration of PROAFTN methodology for acute leukemia diagnosis, *Telemedicine Journal and e-Health*, 11(6), pp. 652-9.

Bell, D., Gray, T. and Haggett, C. (2005) - The 'Social Gap' in Wind Farm Siting Decisions: Explanations and Policy Responses, Environmental Politics, 14(4), pp. 460-77.

Bell, R. C. (2003) - The Repertory Grid Technique, in *International Handbook of Personal Construct Psychology*, F. Fransella (ed.), John Wiley & Sons Ltd., Chichester, England, pp. 3-20.

Benson, J. (2005) - The Visualization of Windfarms, in *Visualization in Landscape and Environmental Planning: technology and applications*, I. Bishop and E. Lange (eds.), Taylor & Francis, London, pp. 184-92.

Bergen, S., Fridley, J., Ganter, M. and Schiess, P. (1995) - Predicting the Visual Effect of Forest Operations, *Journal of Forestry*, 93(2), pp. 33-7.

Bishop, I. (2002) - Determination of thresholds of visual impact: the case of wind turbines, *Environment and Planning B*, 29(5), pp. 707-18.

Bishop, I. (2003) - Assessment of visual qualities, impacts and behaviors in the landscape by using measures of visibility, *Environment and Planning B*, 30(5), pp. 677-88.

Bishop, I. and Lange, E. (2005) - Trends, challenges and a glimpse of the future, in *Visualization in Landscape and Environmental Planning: technology and applications*, I. Bishop and E. Lange (eds.), Taylor & Francis, London, pp. 261-6.

Bishop, I. and Miller, D. R. (2007) - Visual assessment of off-shore wind turbines: the influence of distance, lighting, haze and movement, *Renewable Energy*, 32(5), pp. 814-31.

Bishop, K. and Proctor, A. (1994) - *Love them or loathe them? Public attitudes towards wind farms in Wales*, Department of City and Regional Planning, University of Wales, Aberystwyth.

Bording, J. (2003) - *Dito - User's manual*, Fraunhofer Institut Autonome Intelligente Systeme, Sankt Augustin, Germany.

BP (2007) - *BP Statistical Review of World Energy: Wind Energy* [Online: http://www.bp.com/sectiongenericarticle.do?categoryId=9017928&contentId=7033483]

Bracken, I. and Martin, D. (1995) - Linkage of the 1981 and 1991 Censuses using surface modelling concepts, *Environment and Planning A*, 27, pp. 379-90.

Brans, J. P. and Vincke, P. (1985) - PROMETHEE. A new family of outranking methods in MCDM., *Management Science*, 31(6), pp. 647-56.

Braunholtz, S. (2003) - Public Attitudes to Windfarms: a survey of local residents in Scotland, MORI Scotland for Scotish Executive [Online: http://www.scotland.gov.uk/library5/environment/pawslr.pdf].

Buckingham Shum, S. J., Selvin, A. M., Sierhuis, M., Conklin, J., Haley, C. B. and Nuseibeh, B. (2005) - Hypermedia Support for Argumentation-Based Rationale: 15 Years on from gIBIS and QOC, Technical Report KMI-05-18, December 2005 [Online: http://kmi.open.ac.uk/publications/pdf/KMI-05-18.pdf.].

Burton, T., Sharpe, D., Jenkins, N. and Bossanyi, E. (2001) - *Wind Energy Handbook*, John Wiley & Sons [Online: http://www.knovel.com/knovel2/Toc.jsp?BookID=1057].

Butler, M. M. and Johnson, D. A. (2003) - *Feasibility of mitigating the effects of wind farms on primary radar*, ETSU W/14/00623/REP, prepared by Alenia Marconi Systems Ltd for the Department of Trade and Industry, June 2003 [Online: http://www.bwea.com/aviation/ams_report.html].

BWEA (1994) - *Best practice guidelines for wind energy development*, British Wind Energy Association, London [Online: http://www.bwea.com/pdf/bpg.pdf] Accessed: 17th February 2004.

BWEA (2004) - *Public attitudes to wind energy in the UK*, BWEA Briefing Sheet, British Wind Energy Association [Online: http://www.bwea.com/ref/surveys.html] Accessed: 22 July 2006.

BWEA (2005) - *Low Frequency Noise and Wind Turbines - Technical Annex*, British Wind Energy Association, February 2005 [Online: http://www.bwea.com/ref/lowfrequencynoise.html].

BWEA (2006a) - *Aviation and wind energy*, British Wind Energy Association [Online: http://www.bwea.com/aviation/] Accessed: 28 November 2006.

BWEA (2006b) - Onshore Planning and Development Update, *Real Power*, no. 8, British Wind Energy Association, p. 27.

BWEA (2007) – *Offshore Wind: Round 2*, British Wind Energy Association [Online: http://www.bwea.com/offshore/round-2.html].

Cai, G. (2005) - Extending distributed GIS to support geo-collaborative crisis management, *Geographic Information Science*, 11(1), pp. 4-14.

Carver, S. (1991) - Integrating multi-criteria evaluation with geographical information systems, *International Journal of Geographical Information Systems*, 5(3), pp. 321-39.

Carver, S., Blake, M., Turton, I. and Duke-Williams, O. (1996) - *Where to dispose of Britain's Nuclear Waste? - Open spatial decision making on the Internet*, School of Geography, University of Leeds, Leeds, Yorkshire, England [Online: http://www.ccg.leeds.ac.uk/mce/] Accessed: 2004 February 17.

Carver, S., Blake, M., Turton, I. and Duke-Williams, O. (1997) - Open spatial decision making: evaluating the potential of the World Wide Web, in *Innovations in GIS 4*, K. Kemp (ed.) Taylor & Francis, London, pp. 267-78.

Carver, S., Evans, A. and Fritz, S. (2002a) - Wilderness Attribute Mapping in the United Kingdom, *International Journal of Wilderness*, 8(1), pp. 24-9.

Carver, S., Evans, A. and Kingston, R. (2002b) - *Exploring environmental decision making using Internet GIS: Public participation in locating a nuclear waste disposal site*, School of Geography, University of Leeds, England [Online: http://www.ccg.leeds.ac.uk/teaching/nuclearwaste/].

Carver, S., Evans, A., Kingston, R. and Turton, I. (2001) - Public participation, GIS and cyberdemocracy: evaluating on-line spatial decision support systems, *Environment and Planning B: Planning and Design*, 28(6), pp. 907-21.

Carver, S., Kingston, R. and Turton, I. (1998) - Accessing GIS over the Web: an aid to Public Participation in Environmental Decision-Making, [Online: http://www.geog.leeds.ac.uk/papers/98-3/].

Carver, S. and Openshaw, S. (1996) - *Using GIS to explore the technical and social aspects of site selection for radioactive waste disposal facilities*, Working paper 96/18, University of Leeds, Leeds, UK [Online: http://www.geog.leeds.ac.uk/wpapers/96-18.pdf].

Carver, S. and Peckham, R. J. (1999) - Using GIS on the Internet for Planning, in *Geographical Information and Planning: European perspectives*, S. Geertman, S. Openshaw and J. Stillwell (eds.), Springer-Verlag, Heidelberg, pp. 371-90.

Cavallaro, F. and Ciraolo, L. (2005) - A multicriteria approach to evaluate wind energy plants on an Italian island, *Energy Policy*, 33(2), pp. 235-44.

Centre for Sustainable Energy and Garrad Hassan (2005) - Community Benefits From Wind Power - A study of UK practice and comparison with leading European countries, 05/1322, Report to the Renewables Advisory Board and the DTI [Online: http://www.cse.org.uk/pdf/sof1091.pdf].

Chiari, G. and Nuzzo, M. L. (2003) - Kelly's Philosophy of Constructive Alternativism, in *International Handbook of Personal Construct Psychology*, F. Fransella (ed.) John Wiley & Sons Ltd., Chichester, England, pp. 3-20.

Chris Blandford Associates (2000) - Review of areas of search for renewable energy development, on behalf of the Department of Trade and Industry, February 2000.

Churcher, C. and Churcher, N. (1999) - Realtime Conferencing in GIS, *Transactions in GIS*, 3(1), pp. 23-30.

Churcher, N. and Churcher, C. (1996) - A Collaborative Approach to GIS, *Proceedings of the 8th Annual Colloquium of the Spatial Information Research Centre*, 9-11 July, University of Otago, New Zealand, pp. 156-63 [Online: http://citeseer.ist.psu.edu/churcher96grouparc.html].

Churchman, C. W. and Ackoff, R. L. (1954) - An Approximate Measure of Value, *Journal of the Operations Research Society of America*, 2(2), pp. 172-87.

Cochran, W. G. (1954) – Some methods for strengthening the common chi-square tests, *Biometrics*, 10: 417-451.

Cohon, J. L. (1978) - *Multiobjective Programming and Planning*, Academic Press, New York.

Conklin, J. (1996) - *Designing Organizational Memory: Preserving Intellectual Assets in a Knowledge Economy* [Online: http://cognexus.org/dom.pdf].

Conklin, J. and Begeman, M. L. (1988) - gIBIS: a hypertext tool for exploratory policy discussion, *Proceedings of the Conference on Computer-Supported Co-operative Work (CSCW' 88),* Portland, Oregon, USA, pp. 140-52.

Connolly, T. M. and Begg, C. E. (2004) - *Database Systems: A Practical Approach to Design, Implementation and Management*, 4th edn., Addison-Wesley.

Craig, W., Harris, T. and Weiner, D. (eds.) (2002) - *Community Empowerment, Public Participation and Geographic Information Science*, Taylor and Francis, London.

Crossland, M. D., Wynne, B. E. and Perkins, W. C. (1995) - Spatial decision support systems: An overview of technology and a test of efficacy, *Decision Support Systems*, 14(3), pp. 219-35.

Czaja, R. and Blair, J. (1995) - *Designing Surveys: a Guide to Decisions and Procedures*, Pine Forge Press, Thousand Oaks, California, USA.

Dawes, R. M. (1982) - The robust beauty of improper linear models in decision making, in *Judgement under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and Tversky (eds.), Cambridge Press University, Cambridge.

De Marchi, B., Funtowicz, S. O., Lo Cascio, S. and Munda, G. (2000) - Combining participative and institutional approaches with multicriteria evaluation. An empirical study for water issues in Troina, Sicily, *Ecological Economics*, 34(2), pp. 267-82.

DEFRA (2000) - UK Climate Change Programme 2000, Department for Environment Food and Rural Affairs, Great Britain, November 2000 [Online: http://www.defra.gov.uk/environment/climatechange/uk/ukccp/2000/index.htm].

deegree.org (2007) – [Online www.deegree.org/].

DETR (1999) - *Circular 02/99: Environmental impact assessment*, Circular that gives guidance on the Town and Country Planning (England and Wales) Regulations 1999, SI 1999 No 293, Department of the Environment, Transport and the Regions [Online: http://www.communities.gov.uk/index.asp?id=1144396].

Densham, P. (1990) - Decision support for settlement reorganization, *PhD thesis, Geography, University of Iowa.*

Densham, P. (1991) - Spatial decision support systems, in *Geographical Information Systems: principles and applications*, D. J. Maguire, M. F. Goodchild and W. Rhind (eds.), Longman, London, vol. 1, pp. 403-12.

Densham, P., Armstrong, M. P. and Kemp, K. (1996) - *Collaborative Spatial Decision-Making - Scientific Report for the Initiative 17 Specialist Meeting*, Report 95-14, National Center for Geographic Information and Analysis (NCGIA), Santa Barbara, California, 16th-19th September [Online: http://www.ncgia.ucsb.edu/research/i17/I-17_home.html].

DeSanctis, G. and Gallupe, R. B. (1987) - A foundation for the study of group decision support systems, *Management Science*, 33(5), pp. 589-609.

Devine-Wright, P. (2005a) - Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy, Wind Energy, 8(2), pp. 125-39.

Devine-Wright, P. (2005b) - Local aspects of renewable energy development in the UK: exploring public beliefs and policy implications, Local Environment, 10(1), pp. 57-69.

DigitalDivide.org (2007) - *Digital Divide: What It Is and Why It Matters*, DigitalDivide.org [Online: http://www.digitaldivide.org/dd/digitaldivide.html] Accessed: June 25, 2007.

Dragicevic, S. and Balram, S. (2004) - A Web GIS collaborative framework to structure and manage distributed planning processes, *Journal of Geographical Systems*, 6(2), pp. 133-53.

Dias, L. C. and Mousseau, V. (2003) - IRIS: A DSS for multiple criteria sorting problems, *Journal of Multi-Criteria Decision Analysis*, 12(4-5), pp. 285-98.

Dias, L. C., Mousseau, V., Figueira, J. and Clímaco, J. N. (2002) - An aggregation/disaggregation approach to obtain robust conclusions with ELECTRE TRI, *European Journal of Operational Research*, 138(2), pp. 332-48.

Dobson, J. E. (1983) - Automated geography, *The Professional Geographer*, 35(2), pp. 135-43.

DTI (2000) - *New and Renewable Energy: Prospects for the 21st Century. Conclusions in Response to the Public Consultation*, Department of Trade and Industry, The Stationery Office, London, February 2000 [Online:

http://www.dti.gov.uk/energy/sources/renewables/policy/renewables-obligation/key-stages-of-the-obligation/page18361.html].

DTI (2001) - *New and Renewable Energy: Prospects for the 21st Century. The Renewables Obligation Statutory Consultation*, Department of Trade and Industry, The Stationery Office, London, August 2001 [Online: http://www.dti.gov.uk/energy/sources/renewables/policy/renewables-obligation/key-stages-of-the-obligation/page18361.html].

DTI (2003) - *Our Energy Future - Creating a Low Carbon Economy*, Energy White Paper, Department of Trade and Industry, The Stationery Office, February 2003 [Online: http://www.dti.gov.uk/energy/whitepaper/].

DTI (2005) - *Non Fossil Fuel Obligation fact sheet 11*, Department for Trade and Industry, October 2005.

DTI (2006a) - *The Energy Challenge: The Energy Review Report 2006*, Department of Trade and Industry, The Stationery Office, London, July 2006 [Online: http://www.dti.gov.uk/energy/whitepaper/].

DTI (2006b) - *Energy Trends: September 2006*, Department of Trade and Industry [Online: http://www.dti.gov.uk/energy/statistics/publications/trends/index.html].

DTI (2006c) - *Renewable Energy: Public Perception*, Department of Trade and Industry [Online: http://www.dti.gov.uk/energy/sources/renewables/planning/public-perception/page18642.html] Accessed: 14 December 2006.

DTI (2007a) - *Digest of United Kingdom Energy Statistics 2007*, Department of Trade and Industry, July 2007 [Online: http://www.dti.gov.uk/energy/statistics/publications/dukes/page39771.html].

DTI (2007b) - *Meeting the Energy Challenge: a White Paper on Energy*, Department of Trade and Industry, The Stationery Office, May 2007 [Online: http://www.dti.gov.uk/energy/whitepaper/page39534.html].

DWEA (2006) - *Guided Tour: the park effect*. Danish Wind Industry Association [Online: http://www.windpower.org/composite-1165.htm] Accessed: 18 January 2006.

East of England Regional Assembly (2004) - East of England Plan, Draft revision to the Regional Spatial Strategy (RSS) for the East of England, December 2004 [Online: http://www.eera.gov.uk/category.asp?cat=452].

Easton, A. (1973) - *Complex Managerial Decision Involving Multiple Objectives*, John Wiley & Sons, New York, NY.

Edwards, W. and Barron, F. H. (1994) - SMARTS and SMARTER: improved simple methods for multiattribute utility measurement, *Organizational Behavior and Human Decision Processes*, 60, pp. 306-25.

EIA (2006) - *International Energy Annual 2004*, Energy Information Administration, May-July 2006 [Online: http://www.eia.doe.gov/iea/].

EIA (2007) - *International Energy Outlook 2007*, DOE/EIA-0484(2006), Energy Information Administration, May 2007 [Online: http://www.eia.doe.gov/oiaf/ieo/index.html].

Ek, K. (2005) - Public and private attitudes towards "green" electricity: the case of Swedish wind power, Energy Policy, 33(13), pp. 1677-89.

EN, RSPB, WWF-UK and BWEA (2001) - *Wind farm development and nature conservation - A guidance document for nature conservation organisations and developers when consulting over wind farm proposals in England*, March 2001 [Online: http://www.bwea.com/pdf/wfd.pdf].

Energy Saving Trust (2005) - *Community Action for Energy: case studies* [Online: http://www.energysavingtrust.org.uk/cafe/casestudies/].

Enquire Within (2006) - *Business Applications of Repertory Grid - Index* [Online: http://www.enquirewithin.co.nz/BUS_APP/business.htm] Accessed: 18 Oct. 2006.

Enviros Consulting Ltd (2005) - The Costs of Supplying Renewable Energy, commissioned by the Department of Trade and Industry, 1 September 2005.

Erickson, W. P., Johnson, G. D. and Young, D. P. (2002) - Summary of anthropogenic causes of bird mortality, *Third International Partners in Flight Conference*, March 20-24, Monterrey, California.

ESRI (1998) - *ESRI Shapefile Technical Description*, Environmental Systems Research Institute, Redland, CA, July 1998 [Online: http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf].

ESRI (2004) - *ArcGIS Server Administrator and Developer Guide: ArcGIS 9*, Environmental Systems Research Institute, Redland, CA [Online: http://support.esri.com/index.cfm?fa=knowledgebase.documentation.listDocs&PID=66] Accessed: 6 May 2007.

ETSU (2000) - *Cumulative effects of wind turbines: report on qualitative public attitude research in Mid-Wales*, Volume 2, Energy Technology Support Unit W/14/00583/REP/2, contractor: Landscape Design Associates, London [Online: http://www.dti.gov.uk/energy/renewables/publications/pdfs/W1400538_2.pdf].

European Parliament and the Council (2001a) - *Assessment of the effects of certain plans and programmes on the environment*, Directive 2001/42/EC, 27 June 2001 [Online: http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_197/l_19720010721en00300037.pdf].

European Parliament and the Council (2001b) - *Promotion of electricity produced from renewable energy sources in the internal electricity market*, Directive 2001/77/EC, 27 September 2001 [Online: http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_283/l_28320011027en00330040.pdf].

Evans, A. J., Kingston, R. and Carver, S. (2004) - Democratic input into the nuclear waste disposal problem: The influence of geographical data on decision making examined through a Web-based GIS, *Journal of Geographical Systems*, 6(2), pp. 117-32.

Evans, J. St. B. T. (1984) - Heuristics and analytic processes in reasoning, *British Journal of Psychology*, 75, pp. 451-68.

Evans, J. St. B. T. (1990) - *Bias in Human Reasoning: causes and consequences*, Lawrence Erlbaum Associates Ltd., 145 pp., East Sussex, UK

Evans, J. St. B. T., Barston, J. L. and Pollard, P. (1983) - On the conflict between logic and belief in syllogistic reasoning, *Memory and cognition*, 11, pp. 295-306.

EWEA (2003) - Focus on public opinion: a summary of opinion surveys on wind power, *Wind Directions*, vol. September/October, pp. 16-33.

EWEA (2005) - *Wind Power Economics*, European Wind Energy Association [Online: http://www.ewea.org/index.php?id=201] Accessed: 14 December 2006.

EWEA (2006) - *Powering Change - EWEA Annual Report*, European Wind Energy Association [Online: http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/ewea-report2006.pdf].

EWEA (2007) - *Offshore Wind*, European Wind Energy Association [Online: http://www.ewea.org/index.php?id=203] Accessed: 15 August 2007.

Faber, B. G., Wallace, W. and Sargent, H. (1994) - Use of Groupware Enabled GIS for Land Resource Allocation Issues, *Proceedings of the Sixth International Symposium on System Analysis and Management Decisions in Forestry*, September, Pacific Grove, CA.

Faber, B. G., Wallace, W. W. and Johnson, G. E. (1998) - Active Response GIS : For resource management spatial decision support systems, *Photogrammetric engineering and remote sensing*, 64(1), pp. 7-11.

Feick, R. D. and Hall, G. B. (1997) - Consensus-building in a Multi-participant Spatial Decision Support System, *Journal of the Urban and Regional Information Systems Association*, 11(2), pp. 17-23.

Feixas, G. and Alvarez, J. M. C. (not dated) - *A Manual for the Repertory Grid* [Online: http://www.terapiacognitiva.net/record/pag/index.htm] Accessed: 18 Oct. 2006.

Fiorino, D. J. (1990) - Citizen participation and environmental risk: A survey of institutional mechanisms, *Science, Technology, & Human Values*, 15(2), pp. 226-43.

Fisher, P. F. (1993) - Algorithm and implementation uncertainty in viewshed analysis, *International Journal Geographical Information Systems*, 7(4), pp. 331-74.

Fisher, P. F. (1995) - An exploration of probable viewsheds in landscape planning, *Environment and Planning B: Planning and Design*, 22(4), pp. 527-46.

Fischer, F. and Forester, J. (1993) - *The Argumentative Turn in Policy Analysis and Planning*, UCL Press, London.

Fischhoff, B. (1982) - Debiasing, in *Judgement under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and A. Tversky (eds.), Cambridge Press University, Cambridge.

Flanders, V. (2007) - *Vincent Flanders' Web Pages That Suck* [Online: http://www.webpagesthatsuck.com/].

Forester, J. (1999) - *The Deliberative Practitioner: Encouraging Participatory Planning Processes*, MIT Press, Cambridge, MA, USA.

Fransella, F. (ed.) (2003) - *International Handbook of Personal Construct Theory*, John Wiley & Sons Ltd, England.

Fransella, F. and Bannister, D. (1977) - *A Manual for Repertory Grid Technique*, Academic Press Inc., London.

Fromm, M. (2003) - Learning and Diagnosis of Learning Results, in *International Handbook of Personal Construct Psychology*, F. Fransella (ed.) John Wiley & Sons, Ltd., Chichester, England, pp. 319-26.

Gaines, B. R. and Shaw, M. L. G. (1993) - Knowledge acquisition tools based on personal construct psychology, *Knowledge Engineering Review*, 8(1), pp. 49-56.

Geldermann, J. and Rentz, O. (2003) - Environmental Decisions and Electronic Democracy, *Journal of multi-criteria decision analysis*, 12(2-3), pp. 77-92.

Geoffrion, A. M. (1983) - Can OR/MS evolve fast enough?, *Interfaces*, 13, pp. 10-25.

Georgopoulou, E., Sarafidis, Y., Mirasgedis, S., Zaimi, S. and Lalas, D. (2003) - A multiple criteria decision-aid approach in defining national priorities for greenhouse gases emissions reduction in the energy sector, *European Journal of Operational Research*, 146(1), pp. 199-215.

Gibson, T. (1998) - The Do-ers Guide to Planning for Real', Neighbourhood Initiatives Foundation, Telford.

Gillings, R. and Wheatley, D. (2000) - Vision, perception and GIS: developing enriched approaches to the study of archaeological visibility, in *Beyond the Map*, G. Lock (ed.) IOS Press, Amsterdam, pp. 1-28.

Gipe, P. (1993) - The Wind Industry's Experience with Aesthetic Criticism, *Leonardo*, 26(3), pp. 234-48.

Gipe, P. (1995) - Wind energy comes of age, Wiley series in sustainable design, Wiley, 536 p., New York.

Gordon, T. and Karacapilidis, N. (1997) - The Zeno argumentation framework, *Proceedings of the 6th international conference on Artificial intelligence and law (ICAIL '97)*, June, New York, USA, ACM Press, pp. 10-8.

Gordon, T., Karacapilidis, N., Voss, H. and Zauke, A. (1997) - Computer-mediated cooperative spatial planning, in *Decision Support Systems in Urban Planning*, H. Timmersmans (ed.) E & FN Spon, pp. 299-309.

Gorry, G. A. and Morton, M. S. (1971) - A framework for management information systems, *Sloan Management Review*, 13(1), pp. 55-70.

Gottsegen, J. (1995) - *Information use in the application of SDSS to land use planning debates*, Position Paper for the First Specialist Meeting for NCGIA Initiative 17 - Collaborative Spatial Decision Making. Santa Barbara, CA. [Online: http://ncgia.ucsb.edu/research/i17/htmlpapers/gottsegen/Gottsegen.html].

Gottsegen, J. (1998) - Using argumentation analysis to access stakeholder interests in planning debates, *Computers, Environment and Urban Systems*, 22(4), pp. 365-79.

Gouveia, C. and Câmara, A. (1999) - Multimedia and Urban Planning, in *Geographical Information and Planning: European perspectives*, S. Geertman, S. Openshaw and Stillwell (eds.), Springer-Verlag, Heidelberg, pp. 391-402.

Greenpeace and Global Wind Energy Council (2006) - *Global Wind Energy Outlook*, 20 September 2006 [Online: http://www.gwec.net/index.php?id=65].

Guitouni, A. and Martel, J.-M. (1998) - Tentative guidelines to help choosing an appropriate MCDA method, *European Journal of Operational Research*, 109, pp. 501-21.

Haggett, C. and Toke, D. (2006) - Crossing the great divide - using multi-method analysis to understand opposition to windfarms, *Public Administration*, 84(1), pp. 103-20.

Haklay, M. E. (2002) - Public Environmental Information Systems: challenges and Perspectives, *PhD thesis, Department of Geography, University College London*, London.

Hämäläinen, R. P., Kettunen, E. and Ehtamo, H. (2001) - Evaluating a Framework for Multi-Stakeholder Decision Support in Water Resources Management, *Group Decision and Negotiation*, 10(4), pp. 331-53.

Hamilton, A., Trodd, N., Zhang, X., Fernando, T. and Watson, K. (2001) - Learning through visual systems to enhance the urban planning process, *Environment and Planning B: Planning and Design*, 28(6), pp. 833-45.

Hams, T., Evans, N. and Taylor, D. (2001) - *Making Renewable Energy a Reality – Setting a Challenging Target for The Eastern Region*, Renewable Energy and Land Planning Study, a report to the East of England Sustainable Development Round Table [Online: http://www.renewableseast.org.uk/images/pdfs/Renewables_Report.pdf].

Harvey, R. (1995) - Eliciting and mapping the attributes of landscape perception: An integration of Personal Construct Theory (PCT) with Geographic Information Systems (GIS), *PhD thesis, School of Landscape Architecture, Edinburgh College of Art, Heriot-Watt University.*

Healey, P. (1992) - Planning through debate, *Town Planning Review*, 63(2), pp. 143-62.

Healey, P. (1993) - The communicative work of development plans, *Environment and Planning B*, 20(1), pp. 88-104.

Healey, P. (1997) - *Collaborative Planning-Shaping Places in Fragmented Societies*, Macmillan Press, London.

Healey, P. (1998) - Building institutional capacity through collaborative approaches to urban planning, *Environment and Planning A*, 30, pp. 1531-46.

Hendriks, P. and Vriens, D. (2000) - From Geographical Information Systems to Spatial Group Decision Support Systems: A Complex Itinerary, *Geographical & Environmental Modelling*, 4(1), pp. 83-104.

Her Majesty's Stationery Office (2004) - *Planning and Compulsory Purchase Act 2004*, London [Online: http://www.opsi.gov.uk/acts/acts2004/20040005.htm].

Higgs, G. (2006) - Integrating multi-criteria techniques with geographical information systems in waste facility location to enhance public participation, *Waste management & Research*, 24(2), pp. 105-17.

Hilhorst, D., Warner, J. and Waalewijn, P. (2002) - Public Participation in Disaster-Prone Watersheds: Time for Multi-Stakeholder Platforms?, *Paper for the Water and Climate Dialogue/Disaster Sites*, 6, Wageningen University.

Hill, M. J., Braaten, R., Veitch, S. M., Lees, B. G. and Sharma, S. (2005) - Multicriteria decision analysis in spatial decision support: the ASSESS analytic hierarchy process and the role of quantitative methods and spatially explicit analysis, *Environmental Modelling & Software*, 20, pp. 955-76.

Hillring, B. and Krieg, R. (1998) - Wind energy potential in southern Sweden - example of planning methodology, *Renewable Energy*, 13(4), pp. 471-9.

Hinshelwood, E. (2001) - Power to the People: community-led wind energy - obstacles and opportunities in a South Wales Valey, *Community Development Journal*, 36(2), pp. 95-110.

Hobbs, B. F., Chakong, V., Hamadeh, W. and Stakhiv, E. Z. (1992) - Does choice of multicriteria method matter? An experiment in water resources planning., *Water Resource Reseach*, 28, pp. 1767-80.

Hobbs, B. F. and Meier, P. (2000) - *Energy Decisions and the Environment: A Guide to the Use of Multicriteria Methods*, 1st edn, Kluwer Academic Publishers, 258 pp.

Hoffer, J. A., Prescott, M. and McFadden, F. R. (2002) - *Modern Database Management*, 6th edn, Prentice Hall International, 638 pp., New Jersey, USA.

Holz, L., Kuczera, G. and Kalma, J. (2006) - Multiple Criteria Decision Making: Facilitating a Learning Environment, *Journal of Environmental Planning and Management*, 49(3), pp. 455-70.

Horita, M. (2000a) - Folding Arguments: A Method for Representing Conflicting Views of a Conflict, *Group Decision and Negotiation*, 9(1), pp. 63-83.

Horita, M. (2000b) - Mapping Policy Discourse with CRANES: Spatial Understanding Support System as a Medium for Community Conflict Resolution, *Environment and Planning B: Planning and Design*, 27(6), pp. 801-14.

Howard, D. (1999) - *Geographic information technologies and community planning: Spatial empowerment and public participation*, Varenius Initiative paper [Online: http://www.ncgia.ucsb.edu/varenius/ppgis/papers/howard.html].

Hudson-Smith, A., Evans, S., Batty, M. and Batty, S. (2002) - *Online Participation: the Woodberry Down experiment*, Working Paper 60, Centre for Advanced Spatial Analysis, University College London, London, UK [Online: http://www.casa.ucl.ac.uk/working_papers/paper60.pdf].

Hudson-Smith, A., Evans, S., Batty, M. and Batty, S. (2003) - Experiments in Web-based PPGIS: multimedia in urban regeneration, in *Advanced Spatial Analysis: The CASA book of GIS*, P. Longley and M. Batty (eds.), Redlands, California, pp. 369-90.

Hwang, C.-L. and Yoon, K. P. (1981) - *Multiple Attribute Decision Making, Methods and Applications - A State of the Art Survey*, Springer-Verlag, Berlin.

IAP2 (2007) - *Public Participation Spectrum*, International Association for Public Participation [Online: http://www.iap2.org/associations/4748/files/spectrum.pdf] Accessed: 23 June 2007.

Iberica2000.org (2005) - *Chilling Statistics: Birds/Windfarms - A Compilation Of Bird Mortality Reports*, Mark Duchamp [Online: http://www.iberica2000.org/Es/Articulo.asp?Id=1875].

Jackson, P. (1999) - *Introduction to Expert Systems*, International Computer Science Series, 3 edn, Addison Wesley Longman, Harlow, England.

Jacobson, I., Christerson, M., Jonsson, P. and Overgaard, G. (1992) - *Object-Oriented Software Engineering: A Use Case Driven Approach*, Addison-Wesley, 524 pp., Reading, MA.

Jacquet-Lagrèze, E. and Siskos, Y. (1982) - Assessing a set of additive utility functions for multi-criteria decision making, the UTA method, *European Journal of Operational Research*, 10, pp. 151-64.

Jacquet-Lagrèze, E. and Siskos, Y. (2001) - Preference disaggregation: 20 years of MCDA experience, *European Journal of Operational Research*, 130(2), pp. 233-45.

Jankowicz, D. (2003) - *The Easy Guide to Repertory Grids*, Wiley, Chichester.

Jankowski, P. (1995) - Integrating geographical information systems and multiple criteria decision-making methods, *International Journal of Geographical Information Science*, 9, pp. 251-73.

Jankowski, P., Andrienko, N. and Andrienko, G. (2001) - Map-centered exploratory approach to multi-criteria spatial decision making, *International Journal Geographical Information Science*, 15(2), pp. 100-27.

Jankowski, P. and Nyerges, T. (2001) - *Geographic Information Systems for Group Decision Making: towards a participatory, geographic information science*, Taylor & Francis, New York.

Jankowski, P., Nyerges, T., Smith, A., Moore, T. J. and Horvath, E. (1997) - Spatial group choice: a SDSS tool for collaborative spatial decision-making, *International Journal of Geographical Information Systems*, 11(6), pp. 577-602.

Jankowski, P., Robischon, S., Tuthill, D., Nyerges, T. and Ramsey, K. (2006) - Design considerations and evaluation of a collaborative, spatio-temporal decision support system, *Transactions in GIS*, 10(3), pp. 335-54.

Jankowski, P. and Stasik, M. (1997) - Design considerations for space and time distributed collaborative spatial decision making, *Journal of Geographic Information and Decision Analysis*, 1(1), pp. 1-8.

Jankowski, P. and Stasik, M. (2006) - An Experimental Study Using SDS Tools for a Participatory Approach to Local Land Use Planning, in *Collaborative GIS*, S. Balram and S. Dragicevic (eds.), Idea Group Publishing, London.

Jermany, P. (2005) - Interview on February, 23rd 2005, Planning Policy Manager, King's Lynn and West Norfolk Borough Council.

Jones, R. M., Coppas, C. V. and Edmonds, E. A. (1997) - GIS support for distributed group-work in regional planning, *International Journal Geographical Information Science*, 11(1), pp. 53-71.

Kahneman, D., Slovic, P. and Tversky, A. (eds.) (1982) - *Judgment under uncertainty: Heuristics and biases*, Cambridge University Press, Cambridge.

Kahneman, D. and Tversky, A. (1982) - On the psychology of prediction, in *Judgment under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and A. Tversky (eds.), Cambridge Press University, Cambridge.

Karacapilidis, N. and Papadias, D. (2001) - Computer Supported Argumentation And Collaborative Decision Making: The Hermes System, *Information Systems*, 26(4), pp. 259-77.

Karacapilidis, N., Papadias, D., Gordon, T. and Voss, H. (1997) - Collaborative environmental planning with GeoMed, *European Journal of Operational Research*, 102(2), pp. 335-46.

Keeney, R. L. (1996) - Value-focused thinking: Identifying decision opportunities and creating alternatives, *European. Journal of Operational Research*, 92, pp. 537-49.

Keeney, R. L. and Raiffa, H. (1976) - *Decision with Multiple Objectives: Preferences and Value Tradeoffs*, Wiley, New York.

Kelly, G. (1955) - *The psychology of personal constructs*, Volumes 1 and 2, W W Norton & Co., New York.

Kelly, G. (1977) - The Psychology of the Unknown, in *New Perspectives in Personal Construct Theory*, D. Bannister (ed.) Academic Press Inc., New York, pp. 1-19.

Kelly, G. (2003) - A Brief Introduction to Personal Construct Theory, in *International Handbook of Personal Construct Psychology*, F. Fransella (ed.) John Wiley & Sons Ltd., Chichester, England, pp. 3-20.

Kempton, W., Firestone, J., Lilley, J., Rouleau, T. and Whitaker, P. (2005) - The Offshore Wind Power Debate: Views from Cape Cod, Coastal Management, 33, p. 119–49.

Keßler, C. (2004) - Design and Implementation of Argumentation Maps, *Diploma thesis, Westfälische Wilhelms-Universitäty Münster, Münster, Germany* [Online: http://www.carstenkessler.de/argumap/].

Keßler, C., Rinner, C. and Raubal, M. (2005a) - An Argumentation Map Prototype to Support Decision-Making in Spatial Planning, *Proceedings of AGILE 2005 - 8th Conference on Geographic Information Science*, 26-28 May, Estoril, Portugal, F. Toppen and M. Painho (eds.), pp. 135-42.

Keßler, C., Wilde, M. and Raubal, M. (2005b) - Using SDI-based public participation for conflict resolution, *Proceedings of the 11th EC-GI & GIS Workshop ESDI: Setting the Framework*, 29th June - 1st July, Alghero, Sardinia.

Khan, J. (2003) - Wind Power Planning in Three Swedish Municipalities, *Journal of Environmental Planning and Management*, 46(4), pp. 563-81.

Kidner, D. B. (1997) - Optimal site selection for wind farms: the role for geographical information systems, *Wind Energy Conversion 1996: Proceedings of the 18th British Wind Energy Association Conference*, September 25-27, Exeter, P. Edwards (ed.), MEP, London, pp. 185-90.

Kidner, D. B., Rallings, P. J. and Ware, J. A. (1997) - Parallel Processing for Terrain Analysis in GIS: Visibility as a Case Study, *Geoinformatica*, 1(2), pp. 183-207.

Kidner, D. B., Sparkes, A. and Dorey, M. (1999) - GIS and Wind Farm Planning, in *Geographic Information and Planning*, J. Stillwell, S. Geertman and S. Openshaw (eds.), Springer-Verlag, Berlin, pp. 203-23.

Kingston, R. (2002) - The role of e-government and public participation in the planning process, *XVI AESOP Congress*, 10-14 July, Volos, Greece [Online: http://www.geog.leeds.ac.uk/papers/02-4/02-4.pdf].

Kingston, R., Carver, S., Evans, A. and Turton, I. (1999) - A GIS for the public: enhancing participation in local decision making, *Proceedings of GIS Research UK (GISRUK)*, University of Southampton, p. 11.

Kingston, R., Carver, S., Evans, A. and Turton, I. (1999) - Virtual Decision Making in Spatial Planning: Web-based Geographical Information Systems For Public Participation In Environmental Decision Making, *International Conference on Public Participation and Information Technology*, October 1999, Lisbon, Portugal.

Kingston, R., Carver, S., Evans, A. and Turton, I. (2000) - Web-Based public participation geographical information systems: an aid to local environmental decision-making, *Computers, Environment and Urban Systems*, 24(2), pp. 109-25.

Klassen, K. and Marjerrison, A. (2002) - *Siting a Wind Turbine Farm in Pipestone County, Minnesota Using a GIS Framework*, Geog 4480 Applied GIS student projects, University of Guelph, California, USA, Winter 2002 [Online: http://www.uoguelph.ca/geography/research/geog4480_w2002/Group04/index.htm].

Kreber, C., Castleden, H., Erfani, N., Lim, J. and Wright, T. (2003) - Exploring the Usefulness of Kelly's Personal Construct Theory in Assessing Student Learning in Science Courses, *Teaching in Higher Education*, 8(3), pp. 431-45.

Krohn, S. and Damborg, S. (1999) - On public attitudes towards wind power, *Renewable Energy*, 16(1), pp. 954-60.

Kunz, W. and Rittel, H. (1970) - *Issues as elements of information systems*, Working Paper No. 131, Institute of Urban and Regional Development, Univ. of California, Berkeley, CA.

Lahti, P., Kangasoja, J. and Huovila, P. (eds.) (2006) - *Electronic and Mobile Participation in City Planning and Management: experiences from INTELCITIES – an Integrated Project of the Sixth Framework Programme of the European Union*, Helsinki, Finland [Online: http://www.vtt.fi/liitetiedostot/all_clusters/IntelCities.pdf].

Lange, E. and Hehl-Lange, S. (2005) - Combining a Participatory Planning Approach with a Virtual Landscape Model for the Siting of Wind Turbines, *Journal of Environmental Planning and Management*, 48(6), pp. 833-52.

Langford, M. and Unwin, D. J. (1994) - Generating and mapping population density surfaces within a geographical information system, *Cartographic Journal*, 31(1), pp. 21-6.

Laurini, R. (1998) - Groupware for urban planning: an introduction, *Computers, Environment and Urban Systems*, 22(4), pp. 317-33.

Laurini, R. (2001a) - *Computer Systems for Public Participation* [Online: http://www.gisig.it/vpc_sommet/CD_Sommet/ws3/articololaurini.pdf].

Laurini, R. (2001b) - *Information Systems for Urban Planning: A Hypermedia Cooperative Approach*, Taylor & Francis, 349 pp., London, England.

Learning-Theories.com (2007) – Knowledge Base and Webliography [Online: http://www.learning-theories.com/].

Lee, J. (1990) - SIBYL: a tool for managing group design rationale, *Proceedings of the 1990 ACM conference on Computer-Supported Cooperative Work,* Los Angeles, California, United States, pp. 79-92 [Online: http://portal.acm.org/citation.cfm?id=99344].

Li, S. (2006) - Web-based collaborative spatial decision support systems: a technological perspective, in *Collaborative GIS*, S. Balram and S. Dragicevic (eds.), Idea Group Publishing, London.

LI/IEMA (2002) - *Guidelines for Landscape and Visual Impact Assessment*, Landscape Institute and Institute of Environmental Management and Assessment, 2nd edn, Spon Press, 166 pp., London.

Llobera, M. (2003) - Extending GIS-based visual analysis: the concept of visualscapes, *International Journal Geographical Information Science*, 17(1), pp. 25-48.

Logical Decisions (2007) - [Online: http://www.logicaldecisions.com/] Accessed: 20 April 2007.

Long, A. (2005) – Interview on March, 2nd 2005, Principal Planning Officer, Breckland District Council.

Lowe, D. G. (1985) - Co-operative structuring of information: the representation of reasoning and debate, *International Journal of Man-Machine Studies*, 23, pp. 97-111.

LUC (2003) - *Wind Turbine Development - Landscape Assessment, Evaluation and Guidance*, conducted for Breckland District Council and King's Lynn and West Norfolk Borough Council, August 2003.

Lynch, P. and Horton, S. (2002) - *Web Style Guide* [Online: http://www.webstyleguide.com/index.html].

Macaulay Institute (1999) - *Cumulative Impact of Wind Turbine Generation*, Macaulay Land Use Research Institute, commissioned by Countryside Council for Wales [Online: http://www.macaulay.ac.uk/ccw/index.html] Accessed: 17 December 2006.

MacEachren, A. M. and Brewer, I. (2004) - Developing a conceptual framework for visually-enabled geocollaboration, *International Journal Geographical Information Science*, 18(1), pp. 1-34.

Maguire, D. J. (1991) - An overview and definition of GIS, in *Geographical Information Systems: principles and applications*, D. J. Maguire, M. F. Goodchild and D. W. Rhind (eds.), Longman, London, vol. 1, pp. 9-20.

Maguire, D. J. (2006) – *ArcGIS Server 9.2: Part I Technology*, GIS Matters: Musings on GIS from Redlands, California, November 2006 [Online: http://gismatters.blogspot.com/2006/11/arcgis-server-92-part-i-technology.html].

Maher, B. (ed.) (1969) - *Clinical Psychology and Personality: The Selected Papers of George Kelly*, Wiley, New York.

Malczewski, J. (1997) - *Unit 127 - Spatial Decision Support Systems* [Online: http://www.ncgia.ucsb.edu/giscc/units/u127/] Accessed: 9 Feb 2007.

Malczewski, J. (1999a) - *GIS and multicriteria decision analysis*, John Wiley & Sons, 392 pp., New York.

Malczewski, J. (1999b) - Spatial Multicriteria Decision Analysis, in *Spatial Multicriteria Decision Making and Analysis: a geographic information sciences approach*, J.-C. Thill (ed.) Ashgate Publishing Ltd, UK, pp. 11-48.

Malczewski, J., Moreno-Sanchez, R., Bojórquez-Tapia, L. A. and Ongay-Delhumeau, E. (1997) - Multicriteria Group Decision-making Model for Environmental Conflict Analysis in the Cape Region, Mexico, *Journal of Environmental Planning and Management*, 40(3), pp. 349-74.

Malczewski J. and Rinner, C. (2005) - Exploring multicriteria decision strategies in GIS with linguistic quantifiers: A case study of residential quality evaluation, *Journal of Geographic Systems*, 7(2), pp. 249-68.

Market Research Associates (1994) - *The Sociological Impact of The Cemmaes Wind Farm Study*, W/13/00300/REP, a report for the Department of Trade and Industry, Harwell, Essex, December 1994.

Martin, D. (1989) - Mapping population data from zone centroid locations, *Transactions of the Institute of British Geographers*, 14, pp. 90-7.

Martin, D. (1996) - An assessment of surface and zonal models of population, *International Journal of Geographical Information Systems*, 10, pp. 973-89.

Martin, D. (2005) - *Personal Communication*, e-mail dated of 23 June 2005.

Martin, D. (2007) – Software: where SurfaceBuilder package can be downloaded from [Online: http://www2.geog.soton.ac.uk/users/martindj/davehome/software.htm] Accessed: 16 August 2007.

Martin, D., Tate, N. J. and Langford, M. (2000) - Refining Population Surface Models: Experiments with Northern Ireland Census Data, *Transactions in GIS*, 4(4), pp. 343-60.

Massam, B. H. (1980) - *Spatial search*, Pergamon Press, Oxford.

Matchware 2006 – ScreenCorder 4 [Online: http://www.matchware.com/en/products/screencorder/default.htm] Accessed: 10 May 2006.

Mavrotas, G., Diakoulaki, D. and Capros, P. (2003) - Combined MCDA–IP Approach for Project Selection in the Electricity Market, *Annals of Operations Research*, 120(1), pp. 159-70.

Mehta, C. R. and Patel, N. R. (1996) - SPSS Exact Tests™ 7.0 for Windows, SPSS Inc., UEA.

Menegolo, L. and Peckham, R. J. (1996) - A fully integrated tool for site planning using multicriteria evaluation techniques with a GIS, *Proceedings of the Join European Conference and Exhibition on Geographical Information*, March 27-29, Barcelona, pp. 117-25.

Mennecke, B. E., Crossland, M. D. and Killingsworth, B. L. (2000) - Is a Map More than a Picture? The Role of SDSS Technology, Subject Characteristics, and Problem Complexity on Map Reading and Problem Solving, *Management Information Systems Quarterly*, 24(4), pp. 601-29.

Miller, D. R. (1996) - Landscape Visualization using DEM data derived from Digital Photogrammetry, *Third International Conference/Workshop on Integrating GIS and Environmental Modeling,* Santa Fe, New Mexico, National Center for Geographic Information and Analysis, Santa Barbara, CA, p. 12 [Online: http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/miller2_david/miller_paper2.html].

Miller, D. R., Dunham, R. A. and Chen, W. (2000) - The application of VR modelling in assessing potential visual impacts of rural development, in *Virtual Reality in Geography*, P. Fisher and D. Unwin (eds.), Taylor & Francis, London, pp. 131-43.

Miller, D. R., Morrice, J. G. and Coleby, A. (2005) - The provision of visualization tools for engaging public and professional audiences, in *Visualization in Landscape and Environmental Planning: technology and applications*, I. Bishop and E. Lange (eds.), Taylor & Francis, London, pp. 175-83.

Miller, D. R., Morrice, J. G., Horne, P. L. and Aspinall, R. J. (1994) - The use of geographical information systems for analysis of scenery in the Cairngorm Mountains, Scotland, in *Mountain Environments and Geographic Information Systems*, M. F. Price and D. I. Heywood (eds.), Taylor & Francis, pp. 119-31.

Miller, D. R., Wherrett, J. R., Morrice, J. G. and Fisher, P. F. (1999) - Geographic modelling of the visual impact of wind turbines, *21st British Wind Energy Association Conference*.

Mitcham, C. (1997) - Justifying Public Participation in Technical Decision Making, *IEEE Technology and Society Magazine*, 16(1), pp. 40-6.

Mitchell, C. (2000) - The England and Wales Non-Fossil Fuel Obligation: history and lessons, *Annual Review of Energy and the Environment*, 25, pp. 285-312.

Monteiro, C. (1996) - Integração de Energias Renováveis na Produção Descentralizada de Electricidade Utilizando SIG, *MSc thesis, Departamento de Engenharia Electrotécnica e de Computadores, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal* [Online: http://power.inescn.pt/claudio/CM_MSc.pdf].

Monteiro, C., Miranda, V., Ramirez-Rosado, I. J., Morais, C., Garcia-Garrido, E., Mendoza-Villena, M., Fernandez-Jimenez, L. A. and Martinez-Fernandez, A. (2001) - Spatial Decision Support System for Site Permitting of Distributed Generation Facilities, *Proceedings of IEEE Power Tech Conference,* Porto, Portugal, vol. 3.

Mousseau, V., Figueira, J. and Naux, J.-P. (2001) - Using assignment examples to infer weights for ELECTRE TRI method: Some experimental results, *European Journal of Operational Research*, 130(2), pp. 263-75.

Mousseau, V., Slowinski, R. and Zielniewicz, P. (2000) - A user-oriented implementation of the ELECTRE TRI method integrating preference elicitation support, *Computers and Operations Research*, 27(7-8), pp. 757-77.

Mousseau, V. and Slowinski, R. (1998) - Inferring an ELECTRE TRI model from assignment examples, *Journal of Global Optimization*, 12(2), pp. 157-74.

Munda, G. (2004) - Social multi-criteria evaluation: methodological foundations and operational consequences, *European Journal of Operational Research*, 158, pp. 662-7.

Munda, G., Gamboa, G., Russi, D. and Garmendia, E. (2006) - *Social Multi-Criteria Evaluation of Renewable Energy Sources: two real world catalan examples - wind-parks in western catalonia: where and how case study*, Report for the research project "Development and Application of a Multicriteria Decision Analysis software tool for Renewable Energy Souces (MCDA-RES) [Online: http://alba.jrc.it/ibss/?cat=16&paged=2].

Mustajoki, J., Hämäläinen, R. P. and Marttunen, M. (2004) - Participatory multicriteria decision support with Web-HIPRE: A case of lake regulation policy, *environmental Modelling and Software*, 19(6), pp. 537-47.

Mustajoki, J., Hämäläinen, R. P. and Marttunen, M. (2006) - Web-based Decision Support in Water Resources Management, *Proceeding of the IASTED International Conference on Environmentally Sound Technology in Water Resources Management*, September 11-13, Gaborone, Botswana, O. Totolo (ed), CD-ROM.

Mysiak, J., Giupponi, C. and Rosato, P. (2005) - Towards the development of a decision support system for water resource management, *Environmental Modelling & Software*, 20(2), pp. 203-14.

National Economic Research Associated (2000) - *Multi-criteria analysis manual*, 1 December 2000 [Online: http://www.communities.gov.uk/index.asp?id=1142251].

NCC (2005) - *Demographic Information Note - Rural and urban area classification 2004*, ref: 4/05, Norfolk County Council, August 2005 [Online: http://www.norfolk.gov.uk/consumption/idcplg?IdcService=SS_GET_PAGE&ssDocName=NCC041025&ssSourceNodeId=&ssTargetNodeId=3066].

Ngo The, A. and Mousseau, V. (2002) - Using assignment examples to infer category limits for the ELECTRE TRI method, *Journal of Multi-Criteria Decision Analysis*, 11(1), pp. 29-43.

Nielsen, J. (2000) - *Designing Web Usability: The Practice of Simplicity*, New Riders Publishing, Indianapolis.

Nielsen, J. (2007) - *Alertbox: Current Issues in Web Usability* [Online: http://www.useit.com/alertbox/].

Nijkamp, P. (1979) - *Multidimensional Spatial Data and Decision Analysis*, Wiley, New York.

Nisbett, R. E. and Ross, L. (1980) - *Human inference: Strategies and shortcomings of social judgements*, Prentice-Hall, Englewood Cliffs, N. J.

Nyerges, T., Jankowski, P., Tuthill, D. and Ramsey, K. (2006) - Collaborative Water Resource Decision Support: Results of a Field Experiment, *Annals of the Association of American Geographers*, 96(4), p. 699–725.

ODPM (2004a) - *Planning for Renewable Energy: A Companion Guide to PPS22*, Office of the Deputy Prime Minister, Great Britain, London, December 2004 [Online: http://www.communities.gov.uk/index.asp?id=1502772].

ODPM (2004b) - *Planning Policy Statement 22 (PPS22): Renewable Energy*, Office of the Deputy Prime Minister, Great Britain, London, August 2004 [Online: http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/downloadable/odpm_plan_030335.pdf].

ODPM (2005a) - *Planning Policy Statement 1 (PPS1): Delivering Sustainable Development*, Office of the Deputy Prime Minister, Great Britain, London, February 2005 [Online: http://www.communities.gov.uk/index.asp?id=1143805].

ODPM (2005b) - *The Planning System: General Principles*, Office of the Deputy Prime Minister, Great Britain, London, January 2005 [Online: http://www.communities.gov.uk/index.asp?id=1143805].

Office of Public Sector Information (2006) - *The Renewables Obligation Order*, Statutory Instrument 2006 No. 1004, Department for Trade and Industry [Online: http://www.opsi.gov.uk/si/si2006/20061004.htm].

Ogden, P. (2005) - *TAN 8 ... Planning Delivering for who?*, The Campaign for the Protection of Rural Wales, Spring 2005 [Online: http://www.cprw.org.uk/pdfs/spring05_tan8.pdf].

Okabe, A. and Sadahiro, Y. (1997) - Variation in count data transferred from a set of irregular zones to a set of regular through the point-in-polygon method, *International Journal Geographical Information Science*, 11, pp. 93-106.

ONS (2003) - *Internet Access - Households and Individuals, First Release*, Office for National Statistics, 16 December 2003 [Online: http://www.statistics.gov.uk/pdfdir/intc1203.pdf].

ONS (2006a) - *Internet Access - Households and Individuals*, First Release, Office for National Statistics, 23 August 2006 [Online: http://www.statistics.gov.uk/pdfdir/inta0806.pdf].

ONS (2006b) - *Rural and Urban Area Classification 2004*, Office for National Statistics, [Online: http://www.statistics.gov.uk/geography/nrudp.asp].

ONS (2007) - *Historical Internet Access - Data on Individual*, Office for Nqational Statistics [Online: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=5672].

Openshaw, S. (1984) - *The modifiable areal unit problem*, Concepts and Techniques in Modern Geography, vol. 38, Geo, 41 pp., Norwich.

Oxera Environmental and Arup Economics and Planning (2002) - *Regional Renewable Energy Assessments: a report to the DTI and the DTLR*, 6th February 2002 [Online: http://www.dti.gov.uk/files/file30589.pdf].

Pasqualetti, M. J. (2002) - Living with wind power in a hostile landscape, in *Wind power in view: energy landscapes in a crowded world*, M. J. Pasqualetti, P. Gipe and R. W. Righter (eds.), Academic Press, San Diego, pp. 153-72.

Pasqualetti, M. J., Gipe, P. and Righter, R. W. (2002a) - A landscape of power, in *Wind power in view: energy landscapes in a crowded world*, M. J. Pasqualetti, P. Gipe and R. W. Righter (eds.), Academic Press, San Diego.

Pasqualetti, M. J., Gipe, P. and Righter, R. W. (eds.) (2002b) - *Wind power in view: energy landscapes in a crowded world*, Academic Press, San Diego.

Peffers, K., Gencler, C. E. and Tuunanen, T. (2003) - Extending Critical Success Factors Methodology to Facilitate Broadly Participative Information Systems Planning, *Journal of Management Information Systems*, 20(1), pp. 51-85.

Peng, Z.-R. and Tsou, M.-H. (2003) - *Internet GIS: distributed geographic information services for the internet and wireless networks*, John Wiley & Sons, Inc., 679 pp., New Jersey.

Percival, S. M. (2001) - *Assessment of the Effects of Offshore Wind Farms on Birds*, ETSU W/13/00565/REP, prepared by Ecology Consulting for the Department for Trade and Industry, Durham, UK.

Percival, S. M., Band, B. and Leeming, T. (1999) - Assessing the ornithological effects of wind farms - developing a standard methodology, *21st British Wind Energy Association Conference*, Cambridge, UK, pp. 161-6.

Perny, P. (1998) - Multicriteria filtering methods based on concordance and non-discordance principles, *Annals of Operations Research*, 80, pp. 137-65.

PGIST (2007) - *Participatory Geographic Information Systems for Transportation - building tools for better decisions* [Online: http://depts.washington.edu/pgist/].

Phillpotts, G. and Cohen, D. (2004) - *Region in Figures - East of England*, Office for National Statistics, Summer 2004 [Online: http://www.statistics.gov.uk/pdfdir/inta1202.pdf].

Pike, S. (2005) - The Use of Repertory Grid Analysis and Importance-Performance Analysis to Identify Determinant Attributes of Universities, *Journal of Marketing for Higher Education*, 14(2), pp. 1-18.

Pomeroy, J. W., Green, M. B. and Fitzgibbon, J. E. (1983) - Evaluation of Urban Riverscape Aesthetics in the Canadian Prairies, *Journal of Environmental Management*, 17(3), pp. 263-76.

Poupart, G. J. (2003) - *Wind farms impact on radar aviation interests*, FES W/14/00614/00/REP, prepared by QinetiQ Ltd. for the Department of Trade and Industry, September 2003 [Online: http://www.dti.gov.uk/energy/page18050.html].

Power, S. (2004) - *Facilitating Planning for Renewable Energy in Wales: Meeting the Target*, Arup Final Report prepared for the Welsh Assembly Government, August 2004 [Online: http://new.wales.gov.uk/topics/planning/planning_research/pubplanresearch/449801/?lang=en].

Power, D. J. (2007) - *A Brief History of Decision Support Systems*. DSSResources.COM, version 4.0 [Online: http://DSSResources.COM/history/dsshistory.html].

Pradhan, S. (2005) - A Web-based Public Participatory Spatial Decision Support System for Wind Farm Siting, *MSc GIS thesis, Geomatic Engineering Department, University College London, London.*

Ramasubramanian, L. and Quinn, A. C. (2004) - Visualizing Alternative Urban Futures Using Spatial Multimedia to Enhance Community Participation and Policymaking, in *GIS for Sustainable Development*, M. Campagna (ed.) CRC Press, Florida.

Ramírez-Rosado, I. J., Monteiro, C., García-Garrido, E., Miranda, V., Fernández-Jiménez, L. A. and Zorzano-Santamaría, P. J. (2005) - Negotiation Aid System to Define Priority Maps for Wind Farm Development, *IEEE Transitions on Power Systems*, 20(2), pp. 618-26.

Revlin, R., Leirer, V., Yopp, H. and Yopp, R. (1980) - The belief bias effect in formal reasoning: The influence of knowledge on logic, *Memory and cognition*, 8, pp. 584-92.

Rinner, C. (1998) - Online maps in GeoMed - Internet mapping, online GIS and their application in collaborative spatial decision making, *Proceedings of International Conference on Geographic Information (GIS PlaNET)*, 7-11 September, Lisbon, Portugal.

Rinner, C. (1999) - Argumentation Maps: GIS-based Discussion Support for Online Planning, *PhD thesis, GMD Research Series No. 22, Sankt Augustin, Germany: University of Bonn* [Online: http://docserver.fhg.de/gmd/1999/research/022.pdf].

Rinner, C. (2001) - Argumentation Maps: GIS-based Discussion Support for On-line Planning, *Environment and Planning B: Planning and Design*, 28(6), pp. 847-63.

Rinner, C. (2003) - Web-based Spatial Decision Support: Status and Research Directions, *Journal of Geographic Information and Decision Analysis*, 7(1), pp. 14-31.

Rinner, C. (2005) - Computer Support for Discussions in Spatial Planning, in *GIS for Sustainable Development*, M. Campagna (ed.) Taylor & Francis, pp. 167-80.

Rinner, C. (2006) - Argumentation Mapping in Collaborative Spatial Decision Making, in *Collaborative GIS*, S. Balram and S. Dragicevic (eds.), Idea Group Publishing, London.

Rinner, C. and Malczewski, J. (2002) - Web-Enabled Spatial Decision Analysis Using Ordered Weighted Averaging (OWA), *Journal of Geographic Systems*, 4(4), pp. 385-403.

Rittel, H. and Webber, M. (1973) - Dilemmas in a general theory of planning, *Policy Sciences*, 4, pp. 155-69.

Robinson, W. S. (1950) - Ecological Correlations and the Behavior of Individuals, *American Sociological Review*, 15, pp. 351-7.

Ross, L. and Anderson, C. A. (1982) - Shortcomings in the attribution process: On the origins and maintenance of erroneous social assessments, in *Judgement under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and A. Tversky (eds.), Cambridge Press University, Cambridge.

Roy, B. (1985) - *Méthodologie Multicritére d'Aide à la Décision*, Économica, Paris, France.

Roy, B. (1991) - The outranking approach and the foundations of ELECTRE methods, *Theory and Decision*, 31(1), pp. 49-73.

Roy, B. (1996) - *Multicriteria Methodology for Decision Aiding*, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Roy, B. and Bouyssou, D. (1993) - *Aide Multicritère à la Décision : Méthodes et Cas*, Production et Techniques Quantitatives Appliquées à la Gestion, Economica, Paris, France.

Roy, B. and Vanderpooten, D. (1996) - The European School of MCDA: Emergence, Basic Features and Current Works, *Journal of Multi-Criteria Decision Analysis*, 5(2), pp. 22-38.

Royal Institution of Chartered Surveyors (2004) - *Wind farms hit house prices* [Online: http://www.rics.org/RICSWEB/getpage.aspx?p=iOMUx46ckEyFim60_1jsHQ] Accessed: 14 December 2006.

Saaty, T. L. (1980) - *The Analytic Hierarchy Process*, McGraw-Hill, New York, NY.

Scottish Executive (2002) - *Planning Advice Note 45: Renewable Energy Technologies*, January 2002 (reviewed) [Online: http://www.scotland.gov.uk/library/pan/pan45-00.asp].

Sheppard, S. R. J. (1989) - *Visual simulation: A User's Guide for Architects, Engineers, and Planners*, Van Nostrand Reinhold, 215 pp., New York.

Shiffer, M. J. (1992) - Towards a collaborative planning system, *Environment and Planning B: Planning and Design*, 19(6), pp. 709-22.

Shiffer, M. J. (1995) - Interactive Multimedia Planning Support: Moving from Stand-Alone Systems to the World Wide Web, *Environment and Planning B: Planning and Design*, 22, pp. 649-64.

Shiffer, M. J. (2001) - Spatial Multimedia for Planning Support, in *Planning Support Systems: Integrating geographical information systems, models, and visualization tools*, R. Brail and R. Klosterman (eds.), ESRI Press, Redlands, California, USA, pp. 361-85.

Sidlar, C. and Rinner, C. (2007) - Analyzing the Usability of an Argumentation Map as a Participatory Spatial Decision Support Tool, *Urban and Regional Information Systems Association (URISA) Journal*, 19(1), pp. 47-55.

Simão, A. (2000) - Planeamento e Gestão de Sistemas de Abastecimento de Água com Recurso à Tecnologia dos SIG - Desenvolvimento de um protótipo de Sistema Espacial de Apoio à Decisão e aplicação a uma rede urbana, *MSc thesis, Civil Engineering, University of Coimbra, Coimbra, Portugal.*

Simão, A. (2006a) - *WePWEP: Web-based Participatory Wind Energy Planning [1]*, Working Paper 105, Centre for Advanced Spatial Analysis, University College London, London, UK [Online: http://www.casa.ucl.ac.uk/publications/workingPaperDetail.asp?ID=105].

Simão, A. (2006b) - *WePWEP: Web-based Participatory Wind Energy Planning [2]*, Working Paper 106, Centre for Advanced Spatial Analysis, University College London, London, UK [Online: http://www.casa.ucl.ac.uk/publications/workingPaperDetail.asp?ID=106].

Simão, A., Densham, P. and Haklay, M. (accepted) - Web-based GIS for Collaborative Planning and Public Participation: and application to the strategic planning of wind farm sites, *Journal of Environmental Management*, accepted for publication.

Simon, H. A. (1960) - *The New Science of Management Decision*, Harper and Row, 273 pp., New York, NY.

Siskos, Y., Grigoroudis, E. and Matsatsinis, N. (2005) - UTA Methods, in *Multiple Criteria Decision Analysis: State of the Art Surveys*, J. Figueira, S. Greco and M. Ehrgott (eds.), Springer, New York, vol. 78 of the International Series in Operations Research and Management Science, pp. 297-344.

South West Renewable Energy Agency (2004) - *The South West Public Engagement Protocol for Wind Energy*, September 2004 [Online: http://www.regensw.co.uk/advice/la-windprotocol.asp].

Sparkes, A. and Kidner, D. (1996) - A GIS for the Environmental Impact Assessment of Wind Farms, *11th ESRI European Conference,* London, England [Online: http://gis.esri.com/library/userconf/europroc96/PAPERS/PN26/PN26F.HTM].

Stasik, M. and Jankowski, P. (1997) - Using Map Objects in the Internet-based Decision Support System, *Proceedings of the ESRI User Conference* [Online: http://gis.esri.com/library/userconf/proc97/proc97/abstract/a438.htm].

Steed, A. and McDonnell, J. (2003) - Experiences with Repertory Grid Analysis for Investigating Effectiveness of Virtual Environments, *Proceeding of 6th Annual International Workshop on Presence*, 6-8 October, Aalborg, Denmark [Online: http://www.cs.ucl.ac.uk/staff/A.Steed/presence2003_fourpage.pdf].

Stillwell, W. G., Seaver, D. A. and Edwards, W. (1981) - A Comparison of Weight Approximation Techniques in Multiattribute Utility Decision Making, *Organization Behavior and Human Performance*, 28(1), pp. 62-77.

Stock, C. and Bishop, I. D. (2005) - Helping rural communities envision their future, in *Visualization for Landscape and Environmental Planning: technology and applications*, I. D. Bishop and E. Lange (eds.), Taylor & Francis, London, pp. 145-51.

Strachan, P. A. and Lal, D. (2004) - Wind Energy Policy, Planning and Management Practice in the UK: Hot Air or a Gathering Storm?, *Regional Studies*, 38(5), pp. 551-71.

Stringer, P. (1976) - Repertory Grids in the Study of Environmental Perception, in *Explorations of Interpersonal Space*, P. Slater (ed.) John Wiley, London.

Stringer, P. (1977) - Participating in Personal Construct Theory, in *New Perspectives in Personal Construct Theory*, D. Bannister (ed.) Academic Press Inc., New York, pp. 299-319.

Sun (2007) - JavaServer Faces Technology [Online: http://java.sun.com/javaee/javaserverfaces/] Accessed: 22 August 2007.

Sustainable Development Commission (2005) - *Wind Power in the UK*, Sustainable Development Commission UK, November 2005 [Online: http://www.sd-commission.org.uk/pages/230505.html].

Szarka, J. and Blühdorn, I. (2006) - *Wind Power in Britain and Germany: explaining contrasting development path*, Anglo-German Foundation for the Study of Industrial Society, November 2006.

Tan, F. B. and Gallupe, R. B. (2006) - Aligning Business and Information Systems Thinking: a cognitive approach, *IEEE Transitions on Engineering Management*, 53(2), pp. 223- 37.

Tang, T. (2006) - *Design and Implementation of a GIS-Enabled Online Discussion Forum for Participatory Planning*, MSc thesis, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Fredericton, Canada [Online: http://gge.unb.ca/Pubs/TR244.pdf].

Tang, T., Zhao, J. and Coleman, D. J. (2005) - Design of a GIS-enabled Online Discussion Forum for Participatory Planning, *Proceedings of the 4th Annual Public Participation GIS Conference*, August, Cleveland State University, Cleveland, Ohio, USA, pp. 16 (CD-ROM).

Taylor, D. (2006) - *Key facts and key figures for the East of England*, Government Office for the East of England, 14 June 2006 [Online: http://www.gos.gov.uk/goeast/our_region/272094/eastenglandkf/].

Taylor, S. E. and Thompson, S. C. (1982) - Stalking the elusive "vividness" effect, *Psychological Review*, 89, pp. 155-81.

The Apache Software Foundation (2007) – Apache Tomcat [Online: http://tomcat.apache.org/].

The Campaign for the Protection of Rural Wales (2005) - *Onshore wind - Current CPRW policy* [Online: http://www.cprw.org.uk/renewenergy_land.htm].

The Highland Council (2006) - *Highland Renewable Energy Strategy and Planning Guidelines*, May 2006 [Online: http://www.highland.gov.uk/yourenvironment/planning/energyplanning/renewbleenergy/highlandrenewableenergystrategy.htm].

The World Bank (1996) - *The World Bank Participation Sourcebook* [Online: http://www.worldbank.org/wbi/sourcebook/sbhome.htm].

Thill, J.-C. (1999) - *Spatial Multicriteria Decision Making and Analysis*, Ashgate Publishing Ltd, Hants, England.

Thøgersen, M. L., Nielsen, P., Sørensen, M. V., Toppenberg, P. and Christiansen, E. S. (2003) - *Applying New Computer-Aided Tools for Wind Farm Planning and Environmental Impact Analysis* [Online: http://www.emd.dk/files/windpro/documentation/EWEA_WindPLAN_Paper.pdf].

Thomas, H. (1995) - Public Participation in Planning, in *British Planning Policy in Transition*, Twedwr-Jones (ed.) UCL Press, London, pp. 168-88.

TNS (2003) - *Attitudes and Knowledge of Renewable Energy Amongst the General Public*, a report prepared for Department of Trade and Industry, Scottish Executive, National Assembly for Wales and Department of Enterprise, Trade and Investment, August 2003 [Online: http://www3.dti.gov.uk/renewables/renew_1.2.1.4a.htm].

Toke, D. (2002) - Wind power in UK and Denmark: can rational choice help explain different outcomes?, *Environmental Politics*, 11, pp. 83-100.

Toke, D. (2005a) - Community Wind Power in Europe and in the UK, *Wind Engineering*, 29(3), pp. 301-8.

Toke, D. (2005b) - Explaining wind power planning outcomes: Some findings from a study in England and Wales, *Energy Policy*, 33, pp. 1527-39.

Toke, D. (2005c) - Will The Government Catch the Wind?, *The Political Quarterly*, 76(1), pp. 48-56.

Toulmin, S. (1958) - *The Uses of Argument*, Cambridge University Press, Cambridge, UK.

Tversky, A. and Kahneman, D. (1982a) - Availability: A heuristic for judging frequency and probability, in *Judgment under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and A. Tversky (eds.), Cambridge Press University, Cambridge.

Tversky, A. and Kahneman, D. (1982b) - Evidential impact of base rates, in *Judgment under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and A. Tversky (eds.), Cambridge Press University, Cambridge.

Tversky, A. and Kahneman, D. (1982c) - Judgment under uncertainty: Heuristics and biases, in *Judgment under uncertainty: Heuristics and biases*, D. Kahneman, P. Slovic and A. Tversky (eds.), Cambridge Press University, Cambridge.

Tweed, C. (1994) - An Intelligent Authoring and Information System for Regulatory Codes and Standards, *International Journal of Construction Information Technology*, 2(2), pp. 53-63.

Tweed, C. (1997) - An Information system to support environmental decision making and debate, in *Evaluation of the built environment for sustainability*, P. S. Brandon, P. L. Lombardi and V. Bentivegna (eds.), E & FN Spon, London, pp. 61-87.

Tweed, C. (1998) - Supporting argumentation practices in urban planning and design, *Computers, Environment and Urban Systems*, 22(4), pp. 351-63.

UNECE (1998) - *Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters*, United Nations Economic Commission for Europe, Aarhus [Online: http://www.unece.org/env/pp/documents/cep43e.pdf].

UNEP (1992) - Rio Declaration on Environment and Development, *The United Nations Conference on Environment and Development*, United Nations Environment Programme, 3-14 June, Rio de Janeiro [Online: http://www.unep.org/Documents/Default.asp?DocumentID=78&ArticleID=1163].

United Nations (1992) - *United Nations Framework Convention on Climate Change*, 9th May 1992, New York, USA [Online: http://unfccc.int/resource/docs/convkp/conveng.pdf] Accessed: 18 March 2003.

United Nations (1997) - *Kyoto Protocol to The United Nations Framework Convention on Climate Change*, 11th December 1997, Kyoto, Japan [Online: http://unfccc.int/resource/docs/convkp/kpeng.pdf] Accessed: 18 March 2003.

University of Newcastle (2002) - *Visual Assessment of Windfarms Best Practice*, Report No. F01AA303A, Commissioned by Scottish Natural Heritage.

Unwin, D. J. (1996) - GIS, spatial analysis and spatial statistics, *Progress in Human Geography*, 20(4), pp. 540-51.

van den Berg, G. P. (2004) - Effects of the wind profile at night on wind turbine sound, *Journal of Sound and Vibration*, 277(4-5), pp. 955-70.

Vincke, P. (1989) - *Multicriteria decision-aid*, Wiley, West Sussex, England.

von Winterfeldt, D. and Edwards, W. (1986) - *Decision Analysis and Behavioral Research*, Cambridge University Press, Cambridge:.

Voogd, H. (1983) - *Multicriteria Evaluation for Urban and Regional Planning*, Pion Limited, London, UK.

Voss, A., Denisovich, I., Gatalsky, P., Gavouchidis, K., Klotz, A., Roeder, S. and Voss, H. (2004) - Evolution of a participatory GIS, *Computers, Environment and Urban Systems*, 28(6), pp. 635-51.

Voss, A., Voss, H., Gatalsky, P. and Oppor, L. (2002) - Group Decision Support for Spatial Planning, *Proceedings of Urban Data Management Symposium (UDMS 2002)*, October 1-4, Prague, Czech Republic [Online: http://edu.fss.uu.nl/medewerkers/ja/DUNES/zeno-white-paper-voss.pdf].

W3Schools (2007) - Browser Display Statistics [Online: http://www.w3schools.com/browsers/browsers_display.asp] Accessed: 22 August 2007.

Walker, G. (1995) - Renewable energy and the public, *Land Use Policy*, 12(1), pp. 49-59.

Ward, L. M. and Russell, J. A. (1981) - Cognitive Set and Perception of Place, *Environment and Behavior*, 13(5), pp. 610-32.

Warren, C., Lumsden, C., O'Dowd, S. and Birnie, R. V. (2005) - Green on green: public perceptions of wind power in Scotland and Ireland, *Journal of Environmental Planning and Management*, 48(6), pp. 853-75.

Weaver, S. and Whitehead, S. (2002) - *Map Manager V8 - User Documentation*, ESRI(UK), Aylesbury, UK, 26 March 2002.

Wiedemann, P. M. and Femers, S. (1993) - Public participation in waste management decision making: Analysis and management of conflicts, *Journal of Hazardous Materials*, 33(3), pp. 355-68.

Wind Energy, Defence and Civil Aviation Interests Working Group (2002) - *Wind Energy and Aviation Interests - Interim Guidelines*, ETSU W/14/00626/REP, Department of Trade and Industry [Online: http://www.bwea.com/pdf/Wind-Energy-and-aviation-interim-guidelines.pdf].

Wind Service Holland (2007) - *Wind Energy Statistics World Wide*, last updated: 9 August 2007 [Online: http://home.wxs.nl/~windsh/stats.html].

Wolsink, M. (1996) - Dutch Wind Power Policy. Stagnating Implementation of Renewables, *Energy Policy*, 24(12), pp. 1079-88.

Wolsink, M. (2000) - Wind power and the NIMBY-myth: institutional capacity and the limited significance of public support, *Renewable Energy*, 21(1), pp. 49-64.

Wolsink, M. (2007) - Wind power implementation: The nature of public attitudes: Equity and fairness instead of 'backyard motives', *Renewable and Sustainable Energy Reviews*, 11(6), pp. 1188-207.

WWEA (2006) - *Statistics March 2006*, World Wind Energy Association, 6 March 2006 [Online: http://www.wwindea.org/home/index.php?option=com_content&task=blogcategory&id=21&Itemid=43].

WWEA (2007) - *New World Record in Wind Power Capacity: 14,9 GW added in 2006*, World Wind Energy Association , 29 January 2007 [Online:

http://www.wwindea.org/home/index.php?option=com_content&task=blogcategory&id=21&Itemid=43].

Yoon, K. P. and Hwang, C.-L. (1995) - *Multiple Attribute Decision Making : An Introduction*, Series on Quantitative Applications in the Social Science, vol. 104, Sage University papers, 88 pp.

Young, B. (1993) - *Attitudes Towards Wind Power: A Survey of Opinion in Cornwall and Devon*, W/12/00354/038/REP, ETSU - Energy Technology Support Unit, Harwell, England.

Zhong, T., Lowry, R., Young, R., Rutherford, S. and Nyerges, T. (2007) - *An Analytic-Deliberative Framework for Transportation Programming*, Presented at the Transportation Research Board 2007 [Online: http://depts.washington.edu/pgist/].

Zhu, W. J., Sørensen, J. N. and Shen, W. Z. (2005) - An aerodynamic noise propagation model for wind turbines, *Wind Engineering*, 29(2), pp. 129-42.

Zhu, X., McCosker, J., Dale, A. P. and Bischof, R. J. (2001) - Web-based decision support for regional vegetation management, *Computers, Environment and Urban Systems*, 25(6), pp. 605-27.

Zopounidis, C. and Doumpos, M. (1999) - A multicriteria decision aid methodology for sorting decision problems: The case of financial distress, *Computational Economics*, 14(3), pp. 197-218.

Zopounidis, C. and Doumpos, M. (2000) - Building additive utilities for multi-group hierarchical discrimination: The M.H.DIS method, *Optimization Methods and Software*, 14(3), pp. 219-40.

Zopounidis, C. and Doumpos, M. (2002) - Multicriteria classification and sorting methods: A literature review, *European Journal of Operational Research*, 138(2), pp. 229-46.

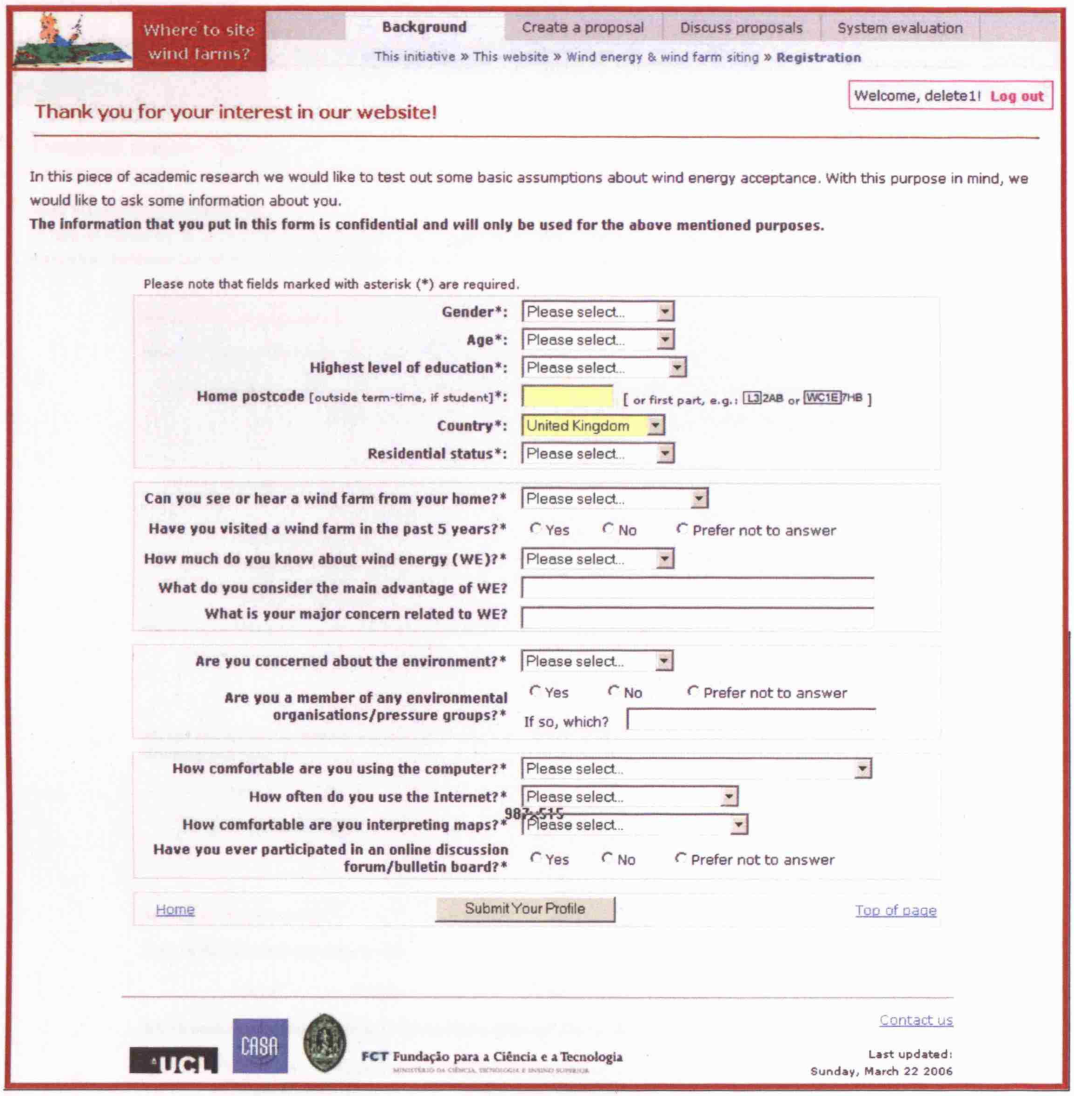
Zopounidis, C. and Doumpos, M. (2002) - Multi-criteria decision aid in financial decision making: Methodologies and literature review, *Journal of Multi-Criteria Decision Analysis*, 11(4-5), pp. 167-86.

Appendices

Appendix A

Registration and feedback questionnaires

Figure A.1 – Registration questionnaire.


Where to site wind farms?

Background | Create a proposal | Discuss proposals | System evaluation

This initiative » This website » Wind energy & wind farm siting » **Registration**

Welcome, delete1! Log out

Thank you for your interest in our website!

In this piece of academic research we would like to test out some basic assumptions about wind energy acceptance. With this purpose in mind, we would like to ask some information about you.

The information that you put in this form is confidential and will only be used for the above mentioned purposes.

Please note that fields marked with asterisk (*) are required.

Gender*: Please select...
Age*: Please select...
Highest level of education*: Please select...
Home postcode [outside term-time, if student]*: [or first part, e.g.: L3 2AB or WC1E 7HB]
Country*: United Kingdom
Residential status*: Please select...

Can you see or hear a wind farm from your home?* Please select...
Have you visited a wind farm in the past 5 years?* Yes / No / Prefer not to answer
How much do you know about wind energy (WE)?* Please select...
What do you consider the main advantage of WE?
What is your major concern related to WE?

Are you concerned about the environment?* Please select...
Are you a member of any environmental organisations/pressure groups?* Yes / No / Prefer not to answer
If so, which?

How comfortable are you using the computer?* Please select...
How often do you use the Internet?* Please select...
How comfortable are you interpreting maps?* Please select...
Have you ever participated in an online discussion forum/bulletin board?* Yes / No / Prefer not to answer

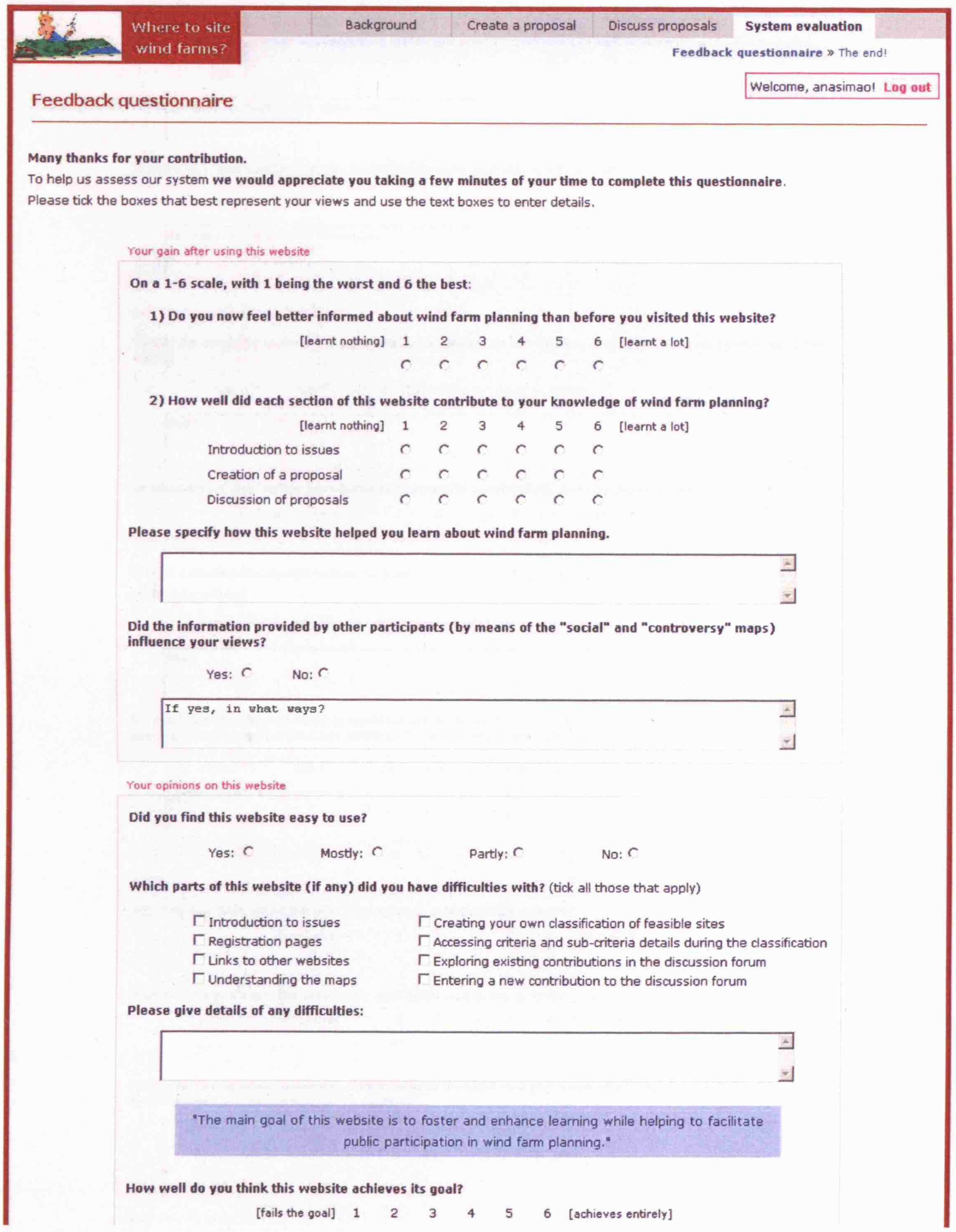
Home | Submit Your Profile | Top of page

Contact us

UCL | CASA | FCT Fundação para a Ciência e a Tecnologia

Last updated: Sunday, March 22 2006

Figure A.2 – Feedback questionnaire (continue).



Where to site wind farms?

Background | Create a proposal | Discuss proposals | **System evaluation**

Feedback questionnaire » The end!

Welcome, anasimao! **Log out**

Feedback questionnaire

Many thanks for your contribution.

To help us assess our system **we would appreciate you taking a few minutes of your time to complete this questionnaire**.

Please tick the boxes that best represent your views and use the text boxes to enter details.

Your gain after using this website

On a 1-6 scale, with 1 being the worst and 6 the best:

1) Do you now feel better informed about wind farm planning than before you visited this website?

[learnt nothing] 1 2 3 4 5 6 [learnt a lot]

2) How well did each section of this website contribute to your knowledge of wind farm planning?

[learnt nothing]	1	2	3	4	5	6	[learnt a lot]
Introduction to issues							
Creation of a proposal							
Discussion of proposals							

Please specify how this website helped you learn about wind farm planning.

Did the information provided by other participants (by means of the "social" and "controversy" maps) influence your views?

Yes: No:

If yes, in what ways?

Your opinions on this website

Did you find this website easy to use?

Yes: Mostly: Partly: No:

Which parts of this website (if any) did you have difficulties with? (tick all those that apply)

- Introduction to issues
- Registration pages
- Links to other websites
- Understanding the maps
- Creating your own classification of feasible sites
- Accessing criteria and sub-criteria details during the classification
- Exploring existing contributions in the discussion forum
- Entering a new contribution to the discussion forum

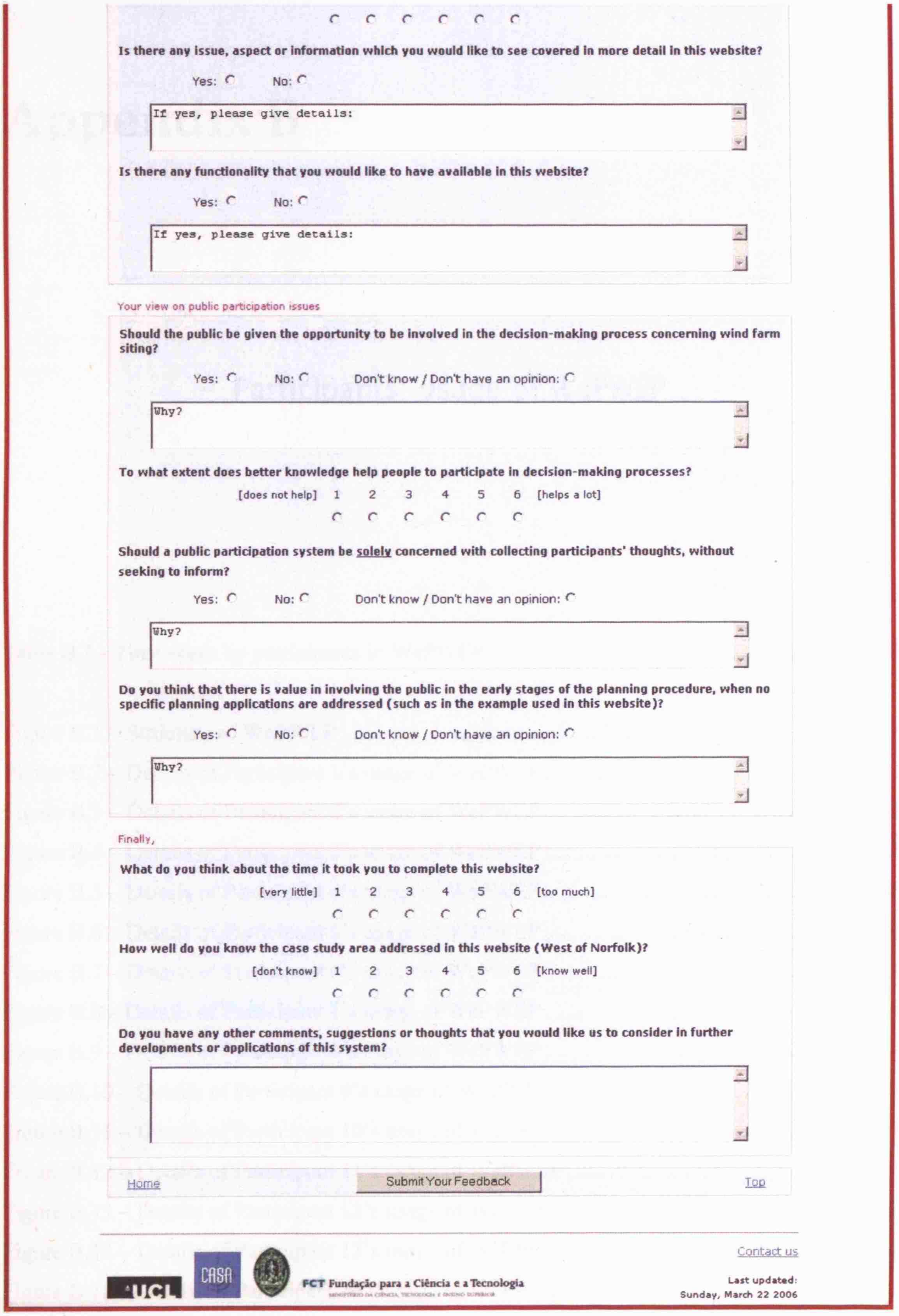
Please give details of any difficulties:

"The main goal of this website is to foster and enhance learning while helping to facilitate public participation in wind farm planning."

How well do you think this website achieves its goal?

[fails the goal] 1 2 3 4 5 6 [achieves entirely]

Figure A.2 – Feedback questionnaire (continued).



Is there any issue, aspect or information which you would like to see covered in more detail in this website?

Yes: No:

If yes, please give details:

Is there any functionality that you would like to have available in this website?

Yes: No:

If yes, please give details:

Your view on public participation issues

Should the public be given the opportunity to be involved in the decision-making process concerning wind farm siting?

Yes: No: Don't know / Don't have an opinion:

Why?

To what extent does better knowledge help people to participate in decision-making processes?

[does not help] 1 2 3 4 5 6 [helps a lot]

Should a public participation system be solely concerned with collecting participants' thoughts, without seeking to inform?

Yes: No: Don't know / Don't have an opinion:

Why?

Do you think that there is value in involving the public in the early stages of the planning procedure, when no specific planning applications are addressed (such as in the example used in this website)?

Yes: No: Don't know / Don't have an opinion:

Why?

Finally,

What do you think about the time it took you to complete this website?

[very little] 1 2 3 4 5 6 [too much]

How well do you know the case study area addressed in this website (West of Norfolk)?

[don't know] 1 2 3 4 5 6 [know well]

Do you have any other comments, suggestions or thoughts that you would like us to consider in further developments or applications of this system?

Home | Submit Your Feedback | Top

Contact us

FCT Fundação para a Ciência e a Tecnologia

Last updated:
Sunday, March 22 2006

Appendix B

Participants' usage of WePWEP

Table B.1 – Time spent by participants in WePWEP, in the registration webpages and in each tier (refer to Figure B.1 for webpages belonging to each tier).

	Total time in					
Participant ID	WepWEP	Registration	1st tier	2nd tier	3rd tier	4th tier
1	1:22:47	0:05:46	0:23:52	0:33:09	0:00:14	0:19:46
2*	1:09:27	0:04:25	0:07:17	0:28:20	0:20:30	0:08:55
3	0:59:42	0:06:20	0:03:25	0:07:45	0:34:45	0:07:27
4	0:58:46	0:02:18	0:11:31	0:19:13	0:18:39	0:07:05
5	1:15:17	0:03:09	0:05:19	0:28:59	0:14:36	0:23:14
6*	1:07:59	0:00:09	0:06:58	0:04:47	0:32:43	0:23:22
7*	1:03:25	0:06:11	0:32:47	0:12:56	0:04:40	0:06:51
8*	1:11:34	0:03:01	0:14:06	0:40:22	0:07:53	0:06:12
9*	1:43:04	0:03:27	0:06:56	0:46:33	0:25:10	0:20:58
10*	0:58:25	0:02:51	0:22:01	0:18:22	0:00:00	0:15:11
11	0:57:58	0:04:20	0:12:29	0:27:37	0:04:55	0:08:37
12	0:54:20	0:02:23	0:34:52	0:08:40	0:03:36	0:04:49
13*	1:53:40	0:05:41	0:31:45	0:32:27	0:16:28	0:27:19
14	1:30:07	0:03:55	0:27:35	0:25:34	0:10:48	0:22:15
15*	1:03:38	0:04:41	0:40:17	0:03:49	0:02:04	0:12:47
16*	1:14:53	0:09:40	0:04:22	0:40:14	0:10:04	0:10:33
17*	0:57:35	0:01:59	0:17:14	0:11:07	0:16:40	0:10:15
18	0:59:21	0:03:24	0:02:48	0:17:23	0:15:30	0:20:16
19	1:39:49	0:03:19	0:50:40	0:22:12	0:10:47	0:12:51
20	1:14:37	0:04:35	0:17:01	0:21:03	0:18:30	0:13:28
21*	0:43:19	0:04:35	0:22:43	0:03:56	0:09:31	0:02:34
22	1:08:18	0:03:49	0:01:32	0:21:58	0:14:21	0:26:38
23*	0:58:35	0:03:31	0:18:11	0:18:26	0:09:05	0:09:22
24	0:57:44	0:04:51	0:12:03	0:07:51	0:20:41	0:12:18
25*	1:19:12	0:03:34	0:10:37	0:28:30	0:17:20	0:19:11
26	1:36:54	0:05:32	0:17:14	0:35:10	0:17:36	0:21:22
27*	1:19:25	0:04:02	0:48:51	0:06:46	0:14:59	0:04:47
28	1:30:36	0:02:34	0:40:50	0:15:22	0:11:11	0:20:39
average	1:12:31	0:04:04	0:19:28	0:21:01	0:13:41	0:14:15
standard deviation	0:16:40	0:01:44	0:13:56	0:11:48	0:08:28	0:07:10
maximum	1:53:40	0:09:40	0:50:40	0:46:33	0:34:45	0:27:19
minimum	0:43:19	0:00:09	0:01:32	0:03:49	0:00:00	0:02:34

* Participant whose interaction with WePWEP was recorded using ScreenCorder.

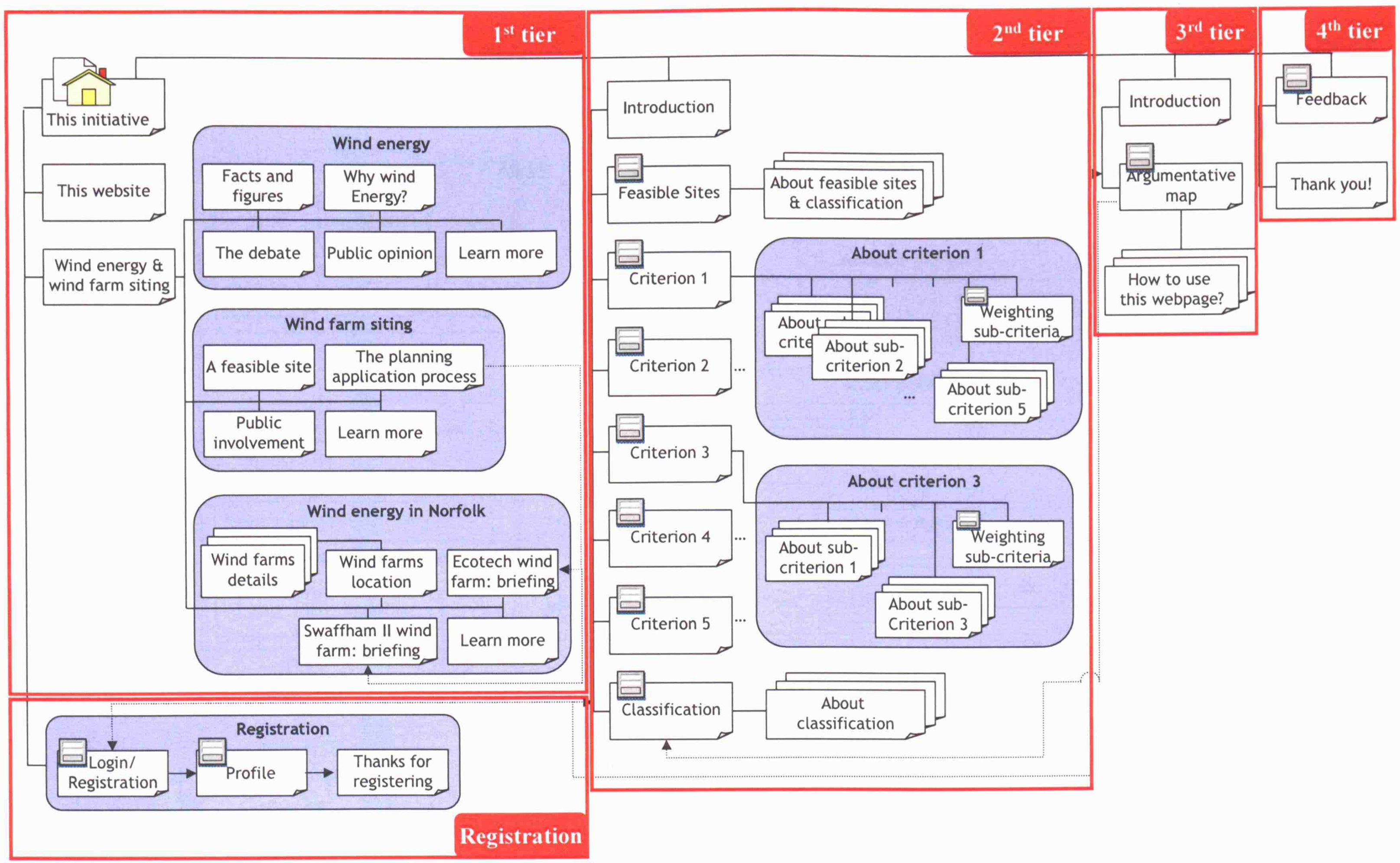


Figure B.1 – Structure of WePWEP.

Total time in the system: 01:22:47

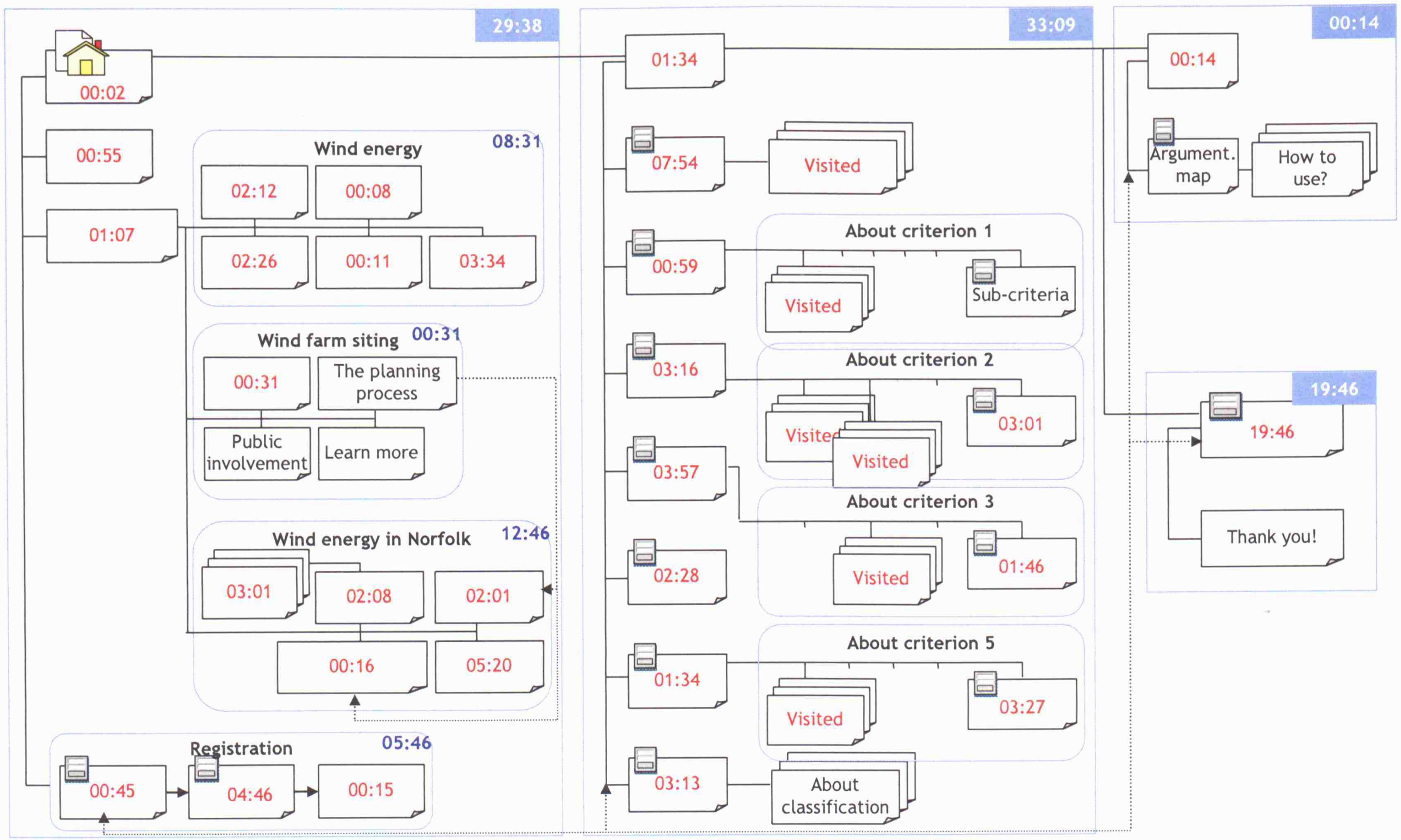


Figure B.2 – Details of Participant 1's usage of WePWEP.

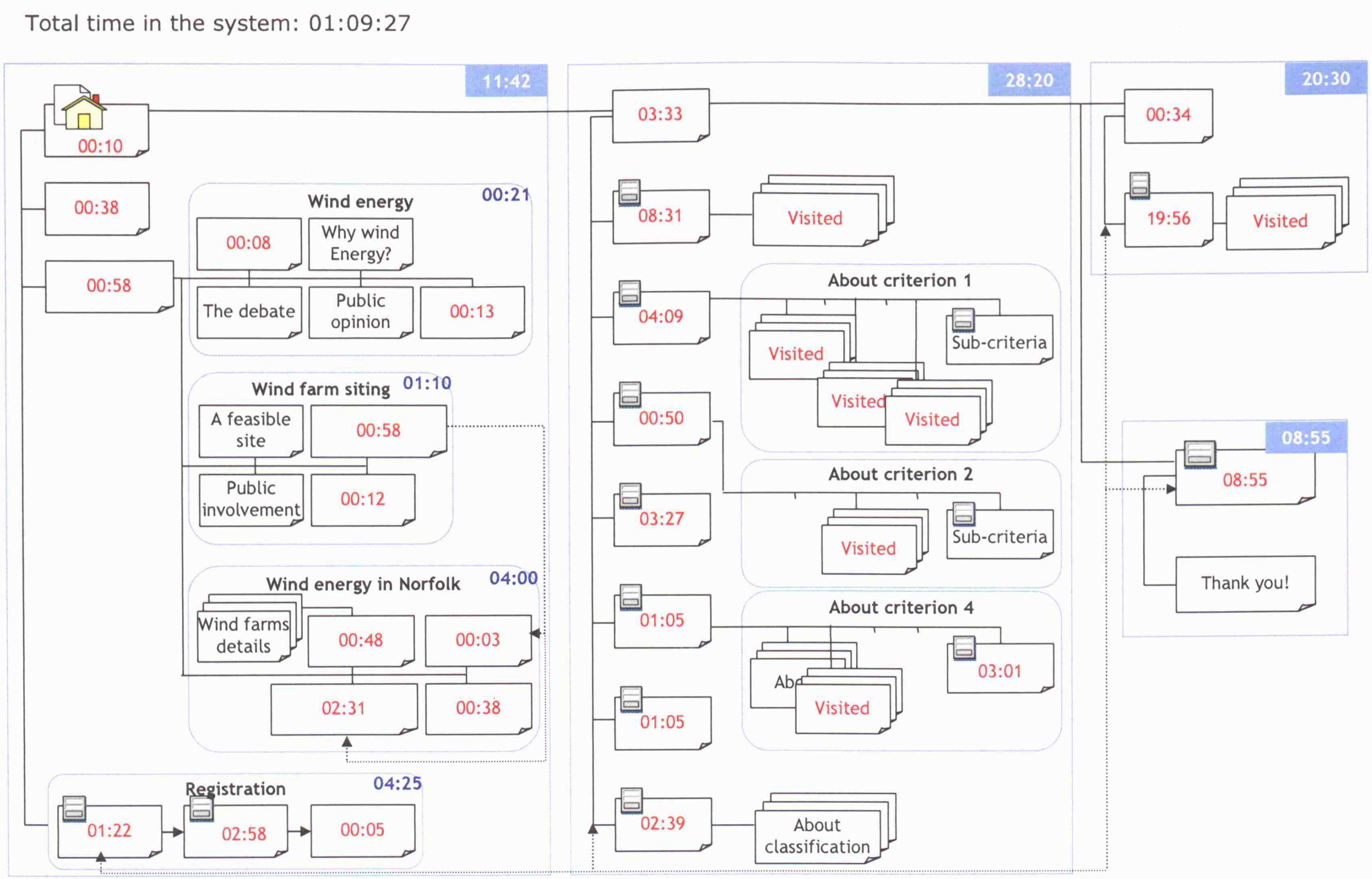


Figure B.3 – Details of Participant 2's usage of WePWEP.

Total time in the system: 00:59:42

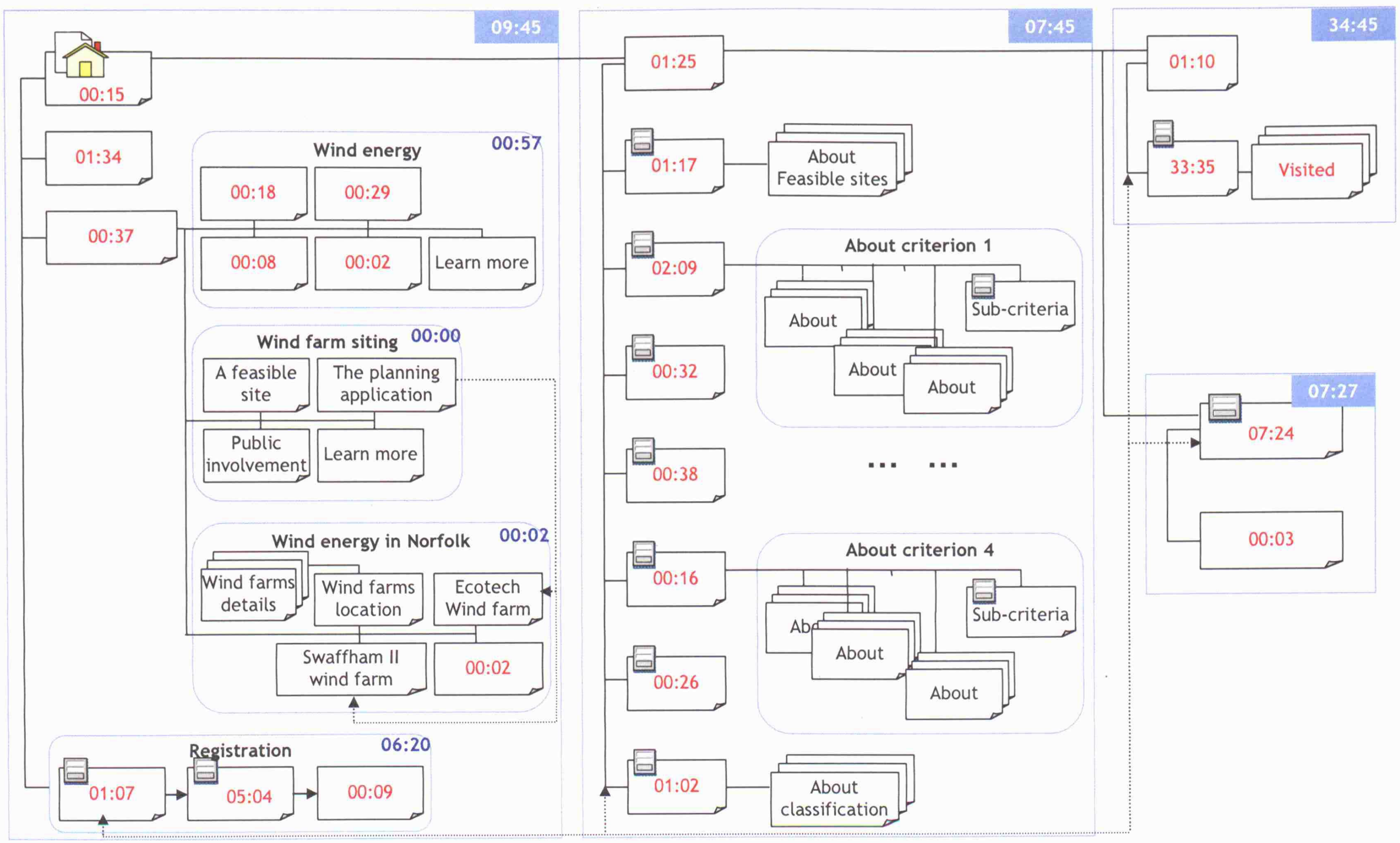


Figure B.4 – Details of Participant 3's usage of WePWEP.

Total time in the system: 00:58:46

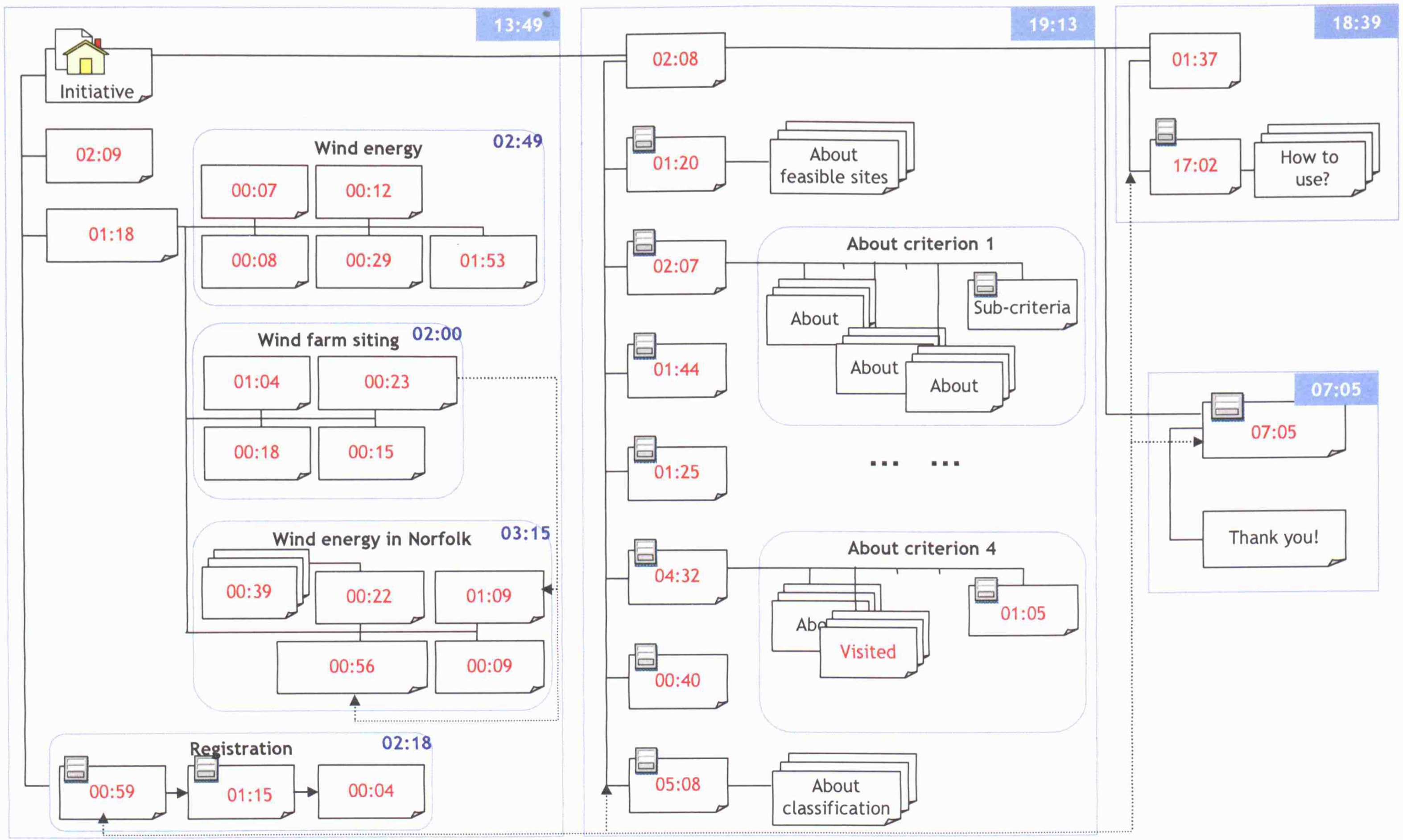


Figure B.5 – Details of Participant 4's usage of WePWEP.

Total time in the system: 01:15:17

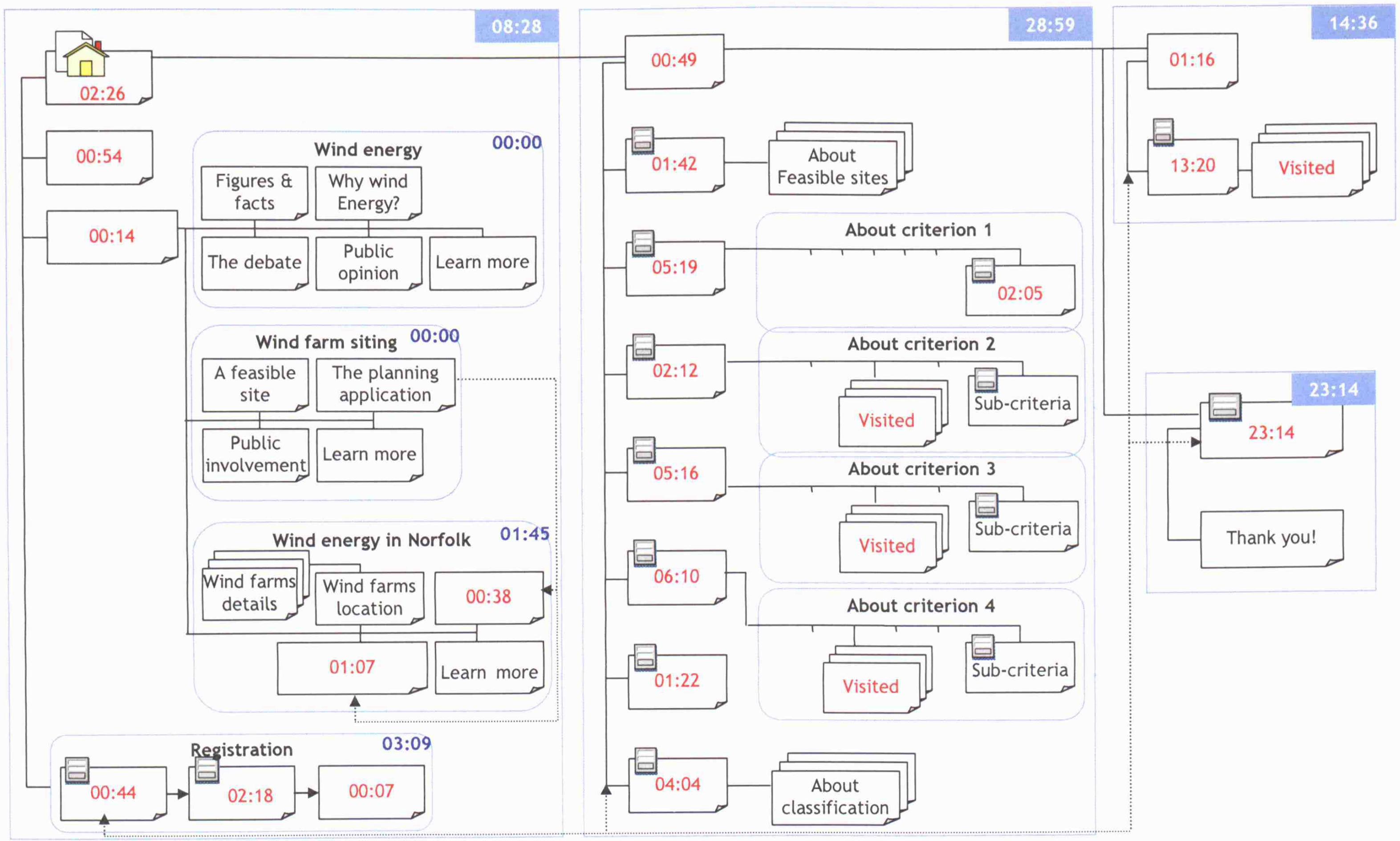


Figure B.6 - Details of Participant 5's usage of WePWEP.

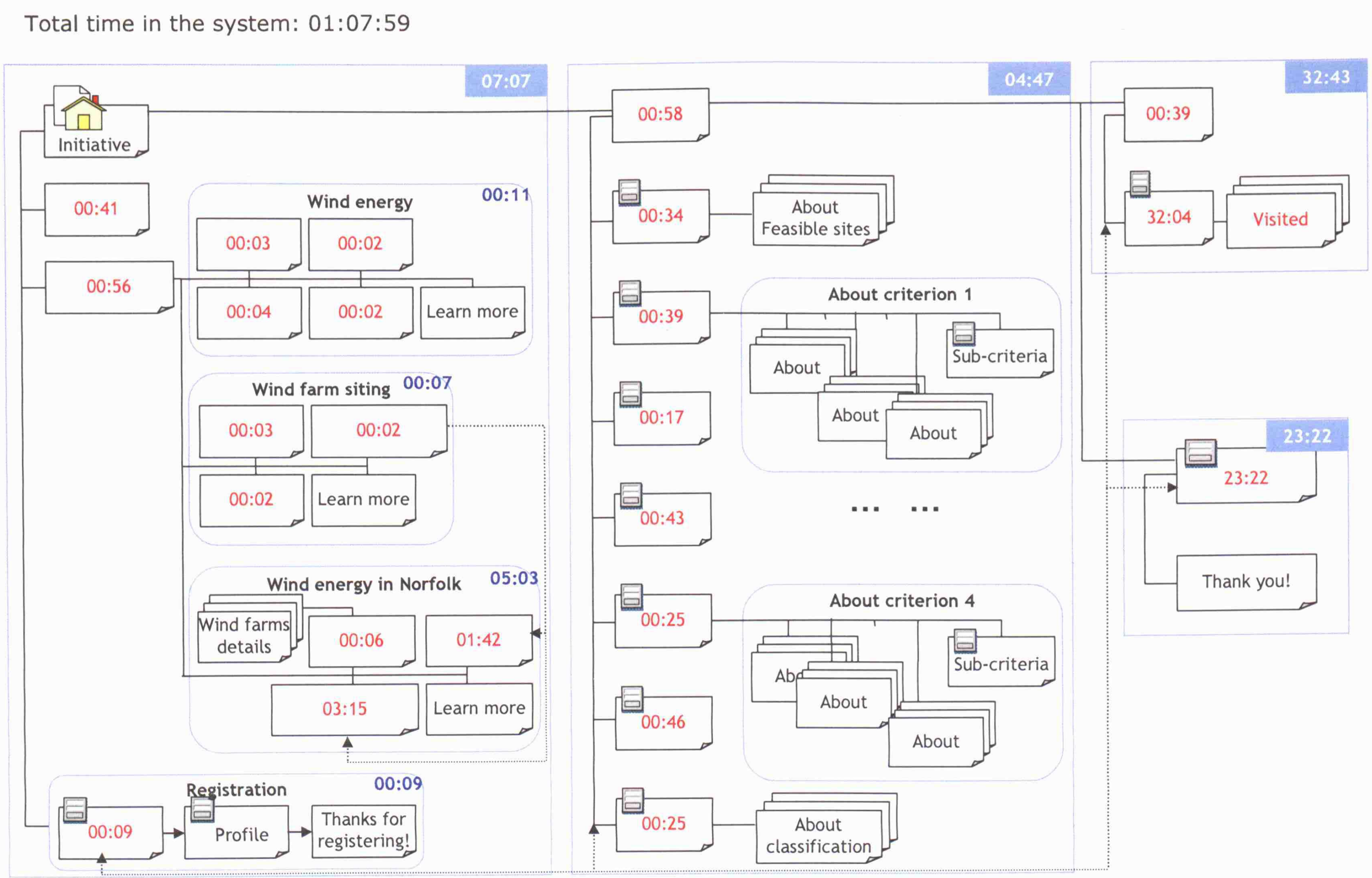


Figure B.7 - Details of Participant 6's usage of WePWEP.

Total time in the system: 01:03:25

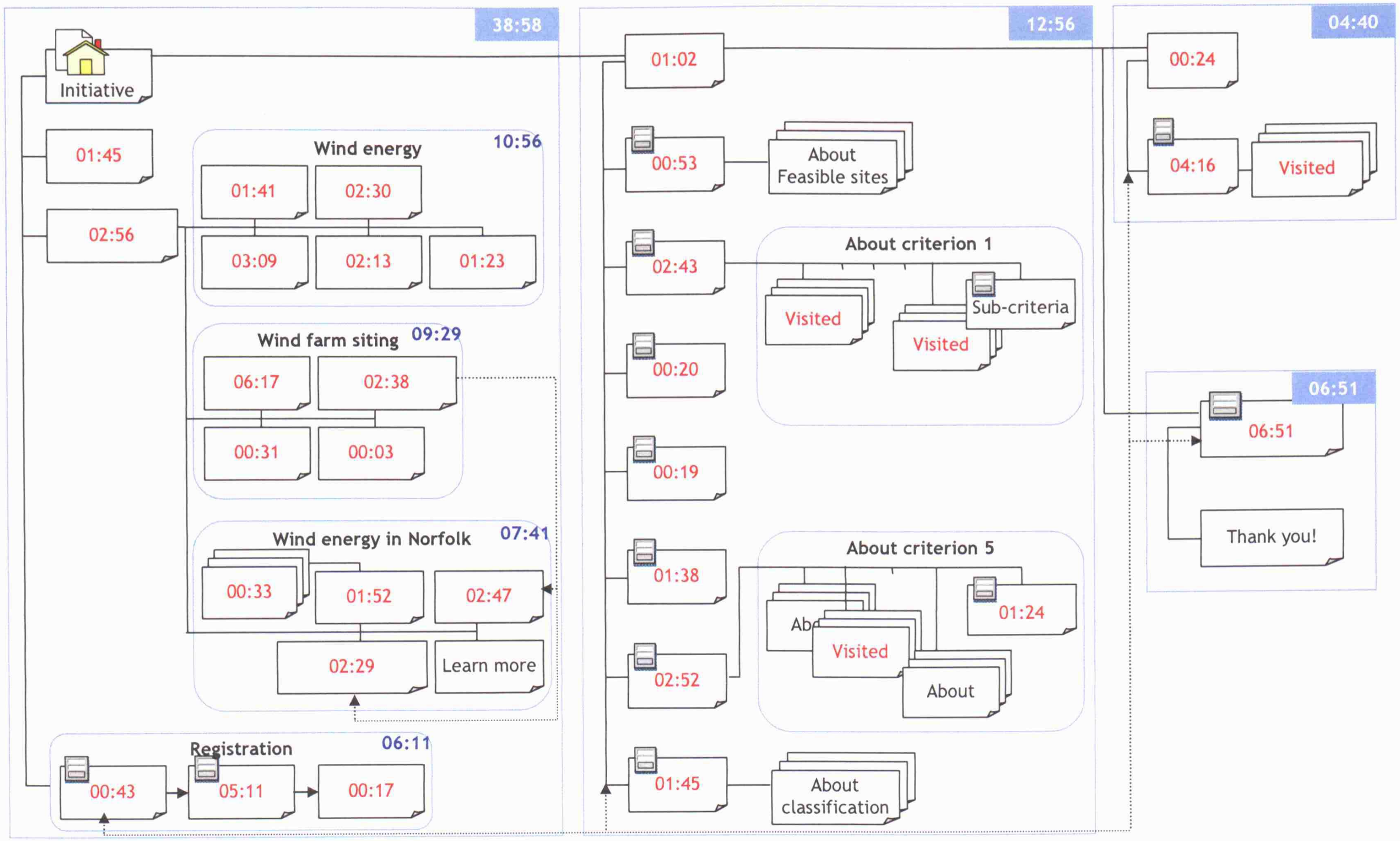


Figure B.8 - Details of Participant 7's usage of WePWEP.

Total time in the system: 01:11:34

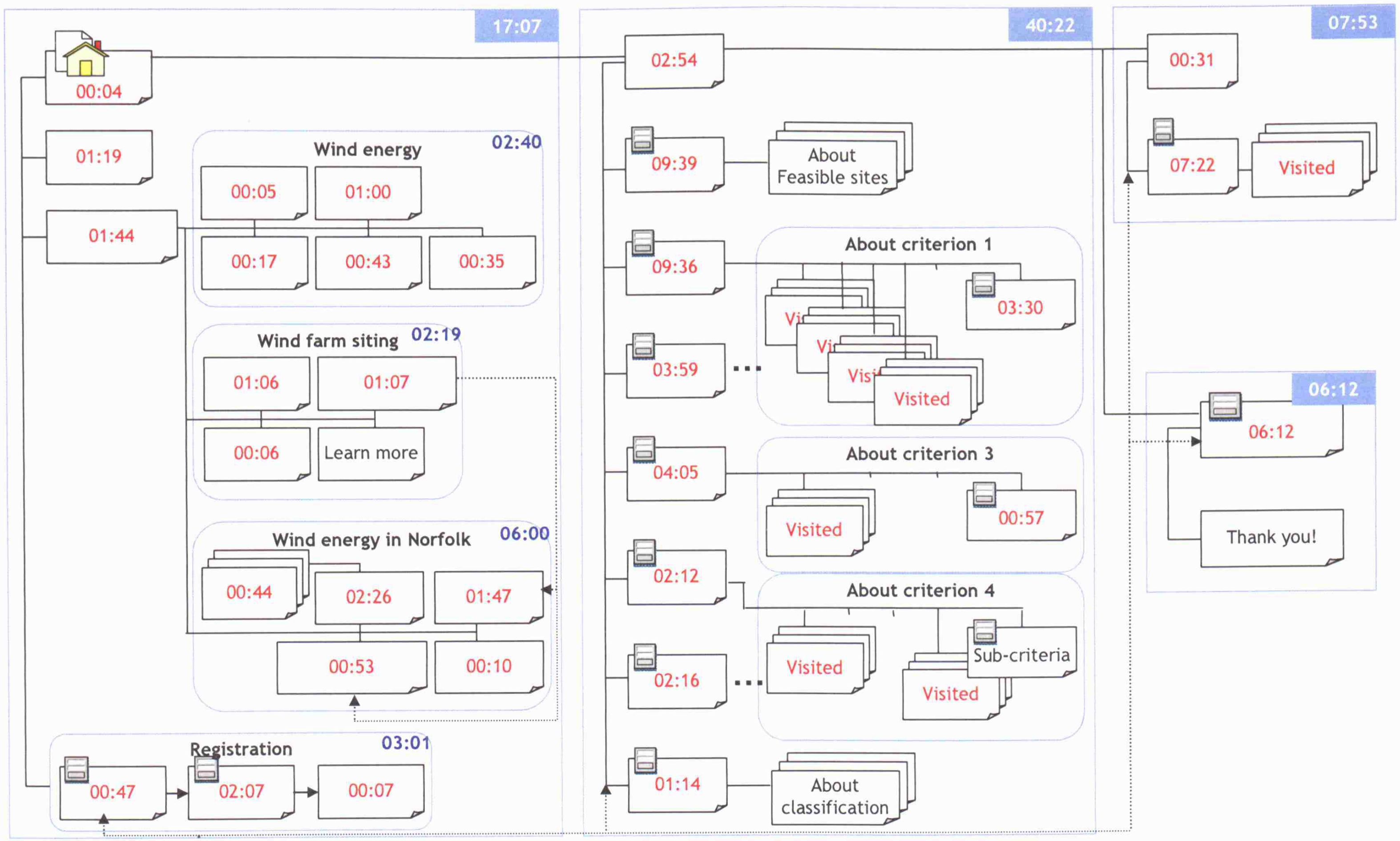


Figure B.9 - Details of Participant 8's usage of WePWEP.

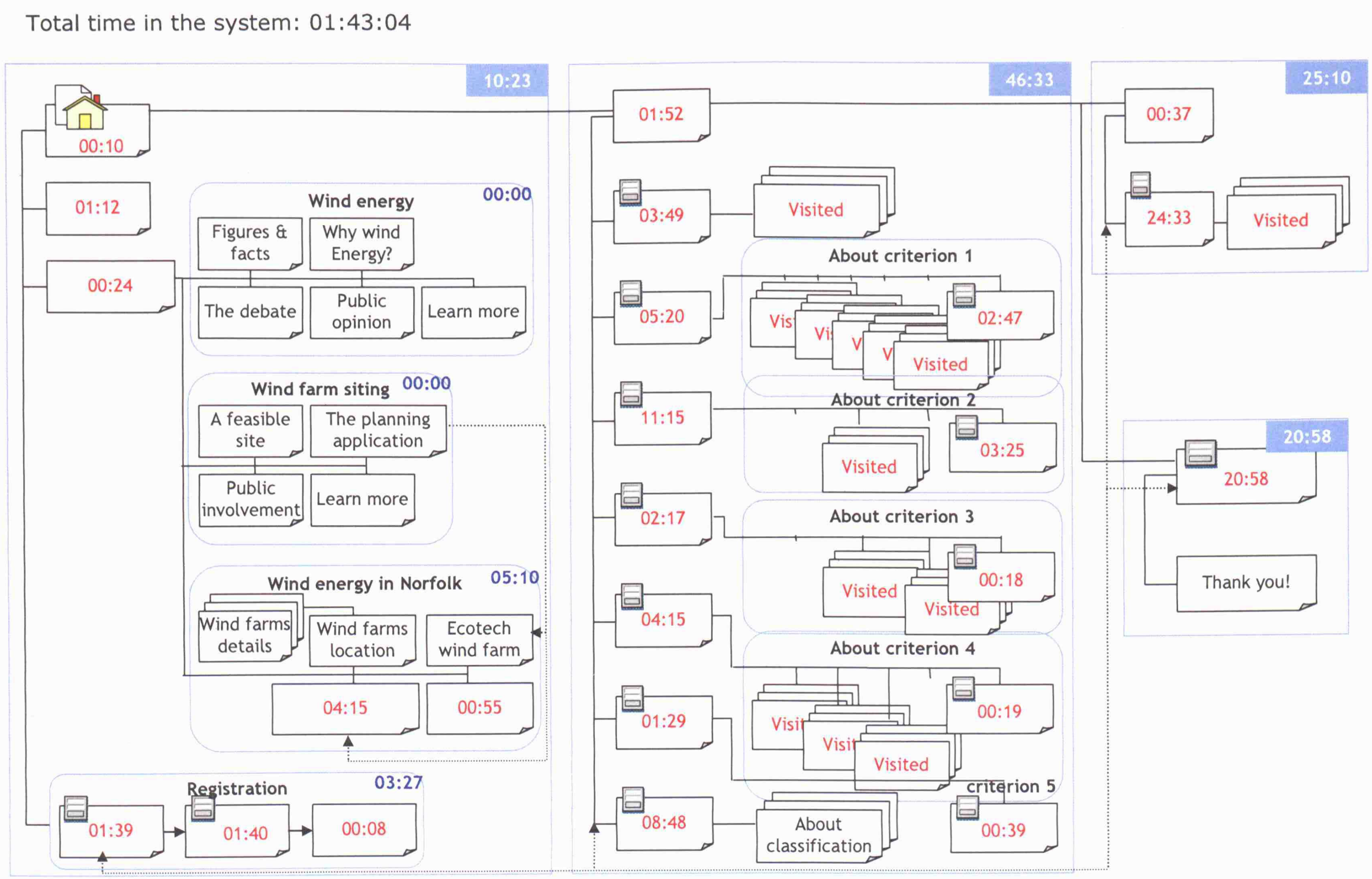


Figure B.10 - Details of Participant 9's usage of WePWEP.

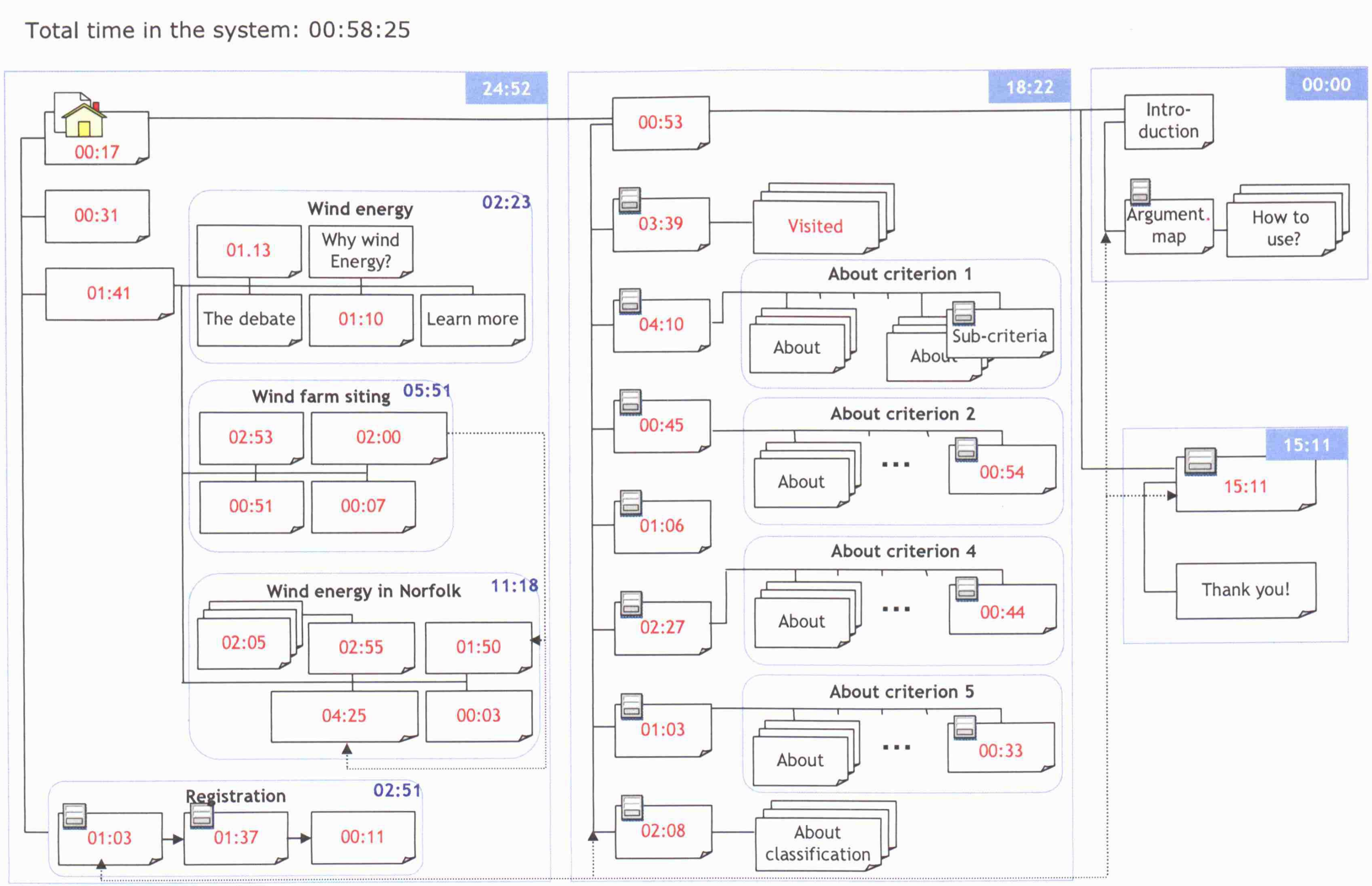


Figure B.11 - Details of Participant 10's usage of WePWEP.

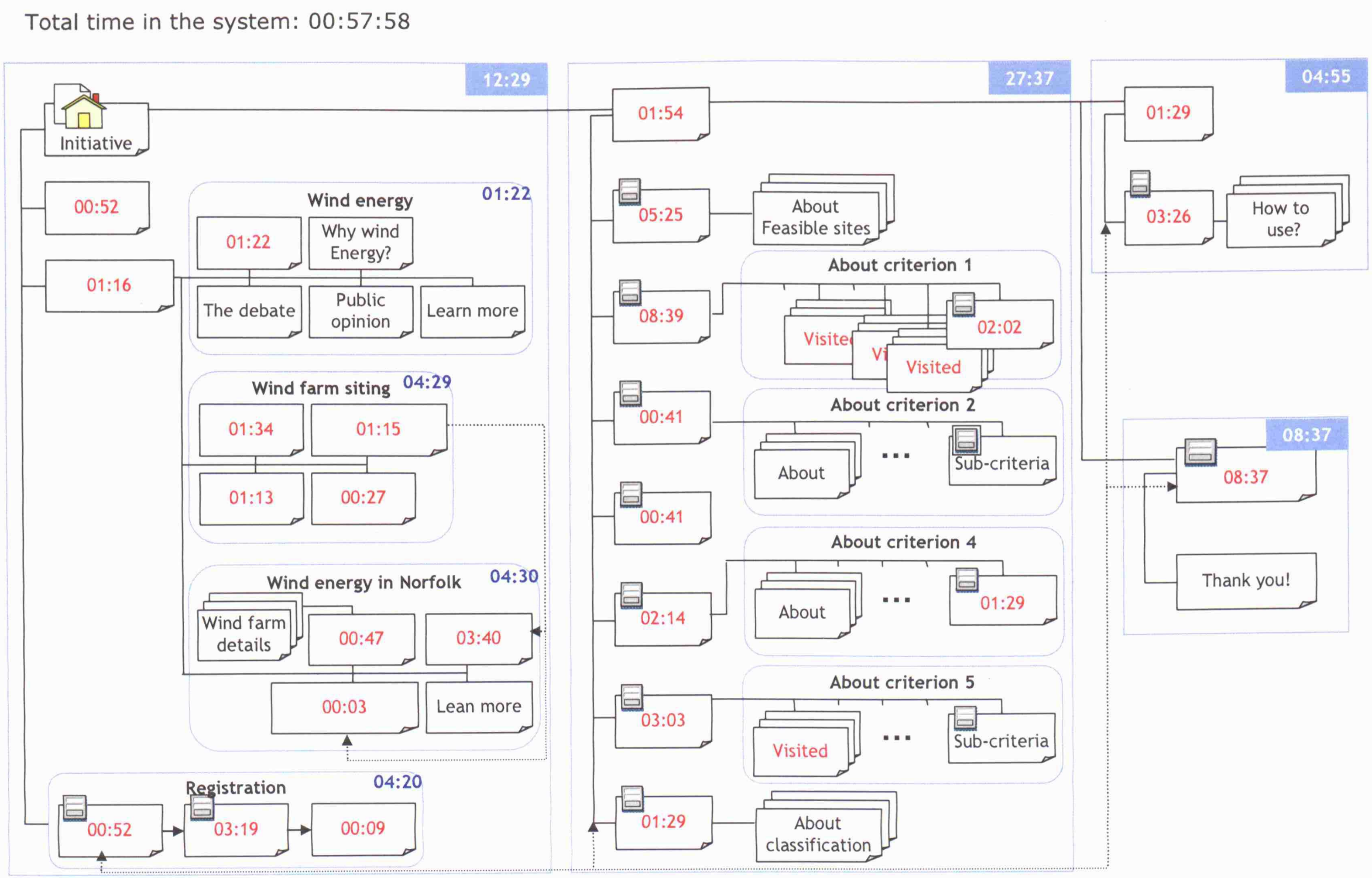


Figure B.12 - Details of Participant 11's usage of WePWEP.

Total time in the system: 00:54:20

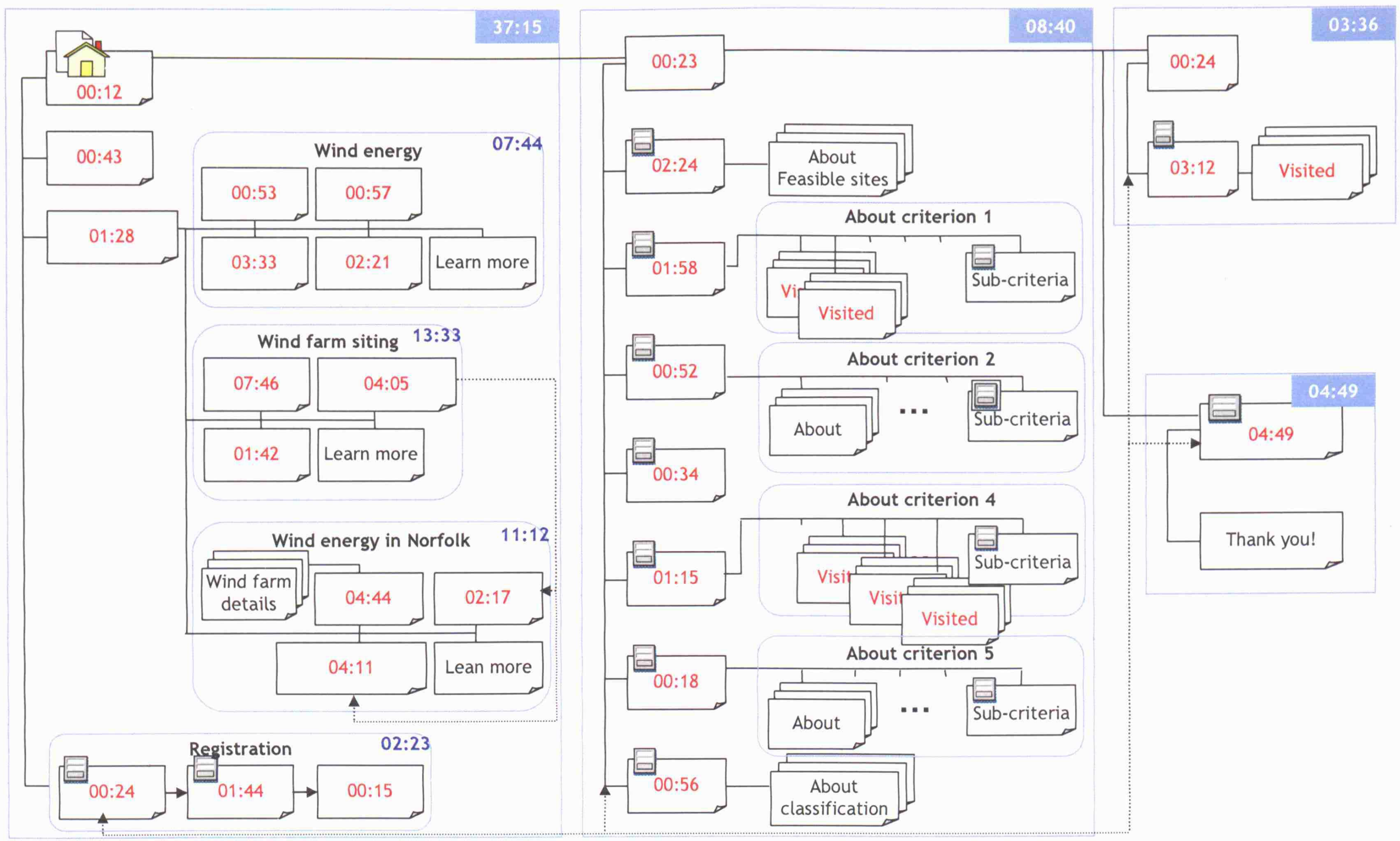


Figure B.13 - Details of Participant 12's usage of WePWEP.

Total time in the system: 01:53:40

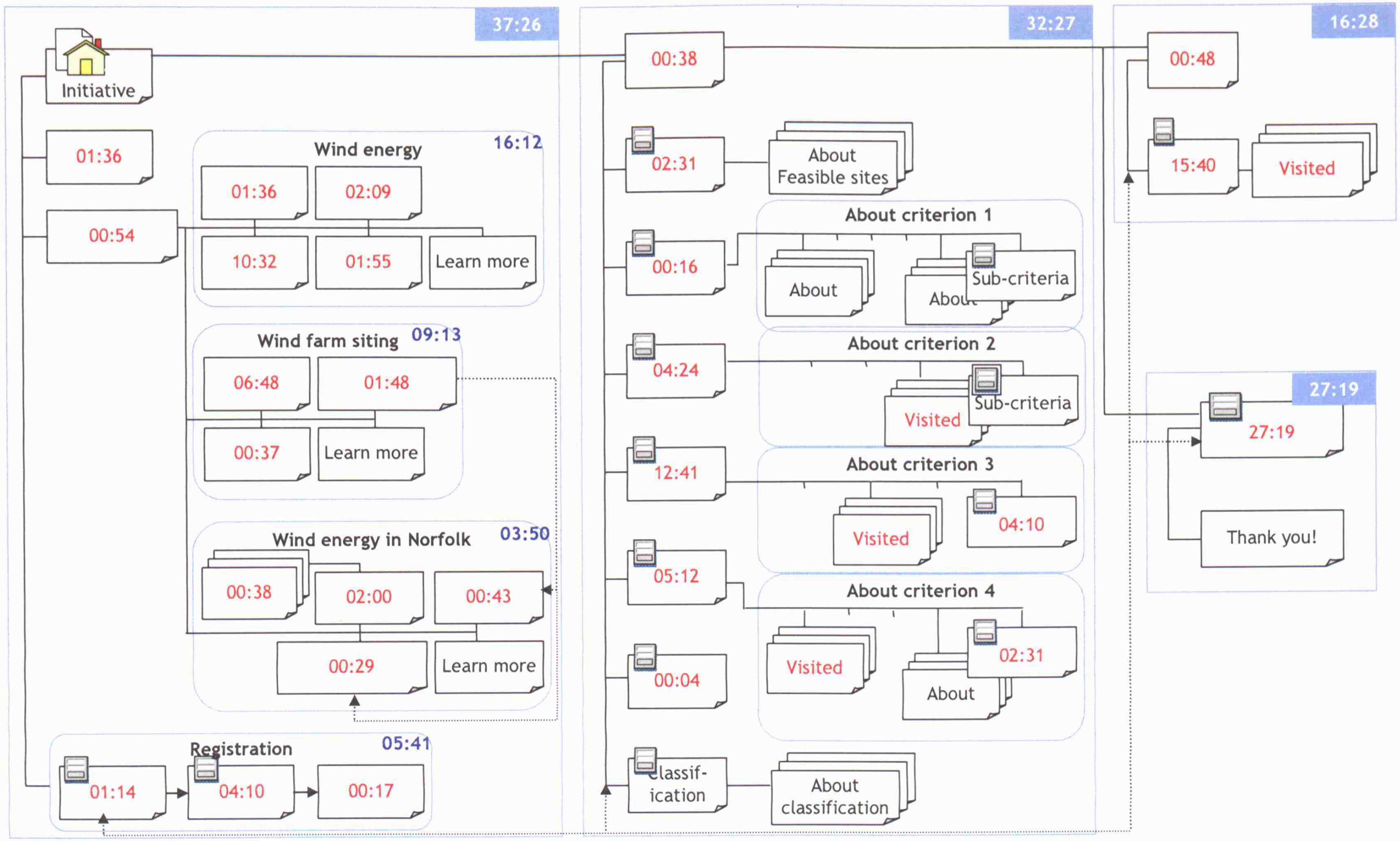


Figure B.14 - Details of Participant 13's usage of WePWEP.

Total time in the system: 01:30:07

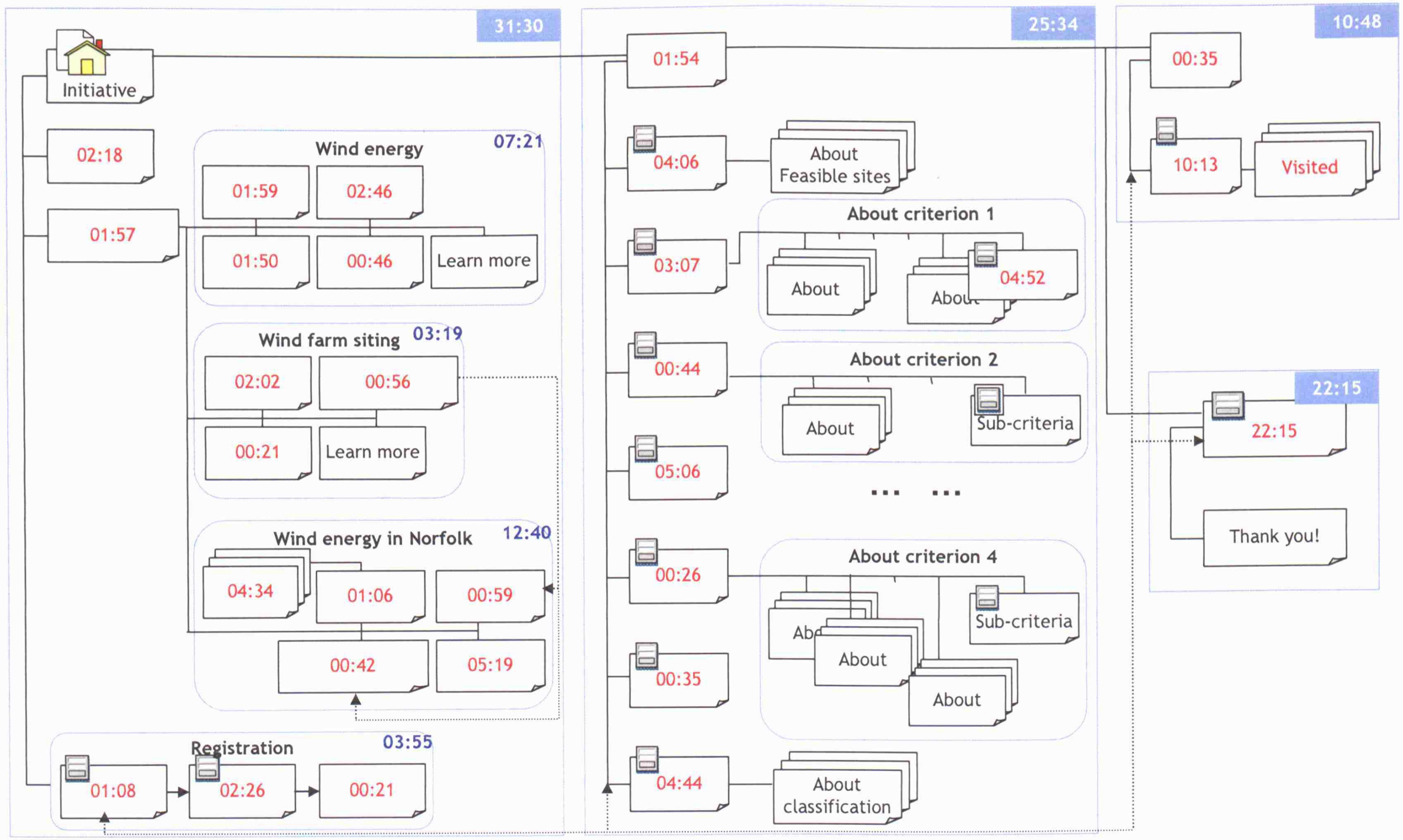


Figure B.15 - Details of Participant 14's usage of WePWEP.

Total time in the system: 01:03:38

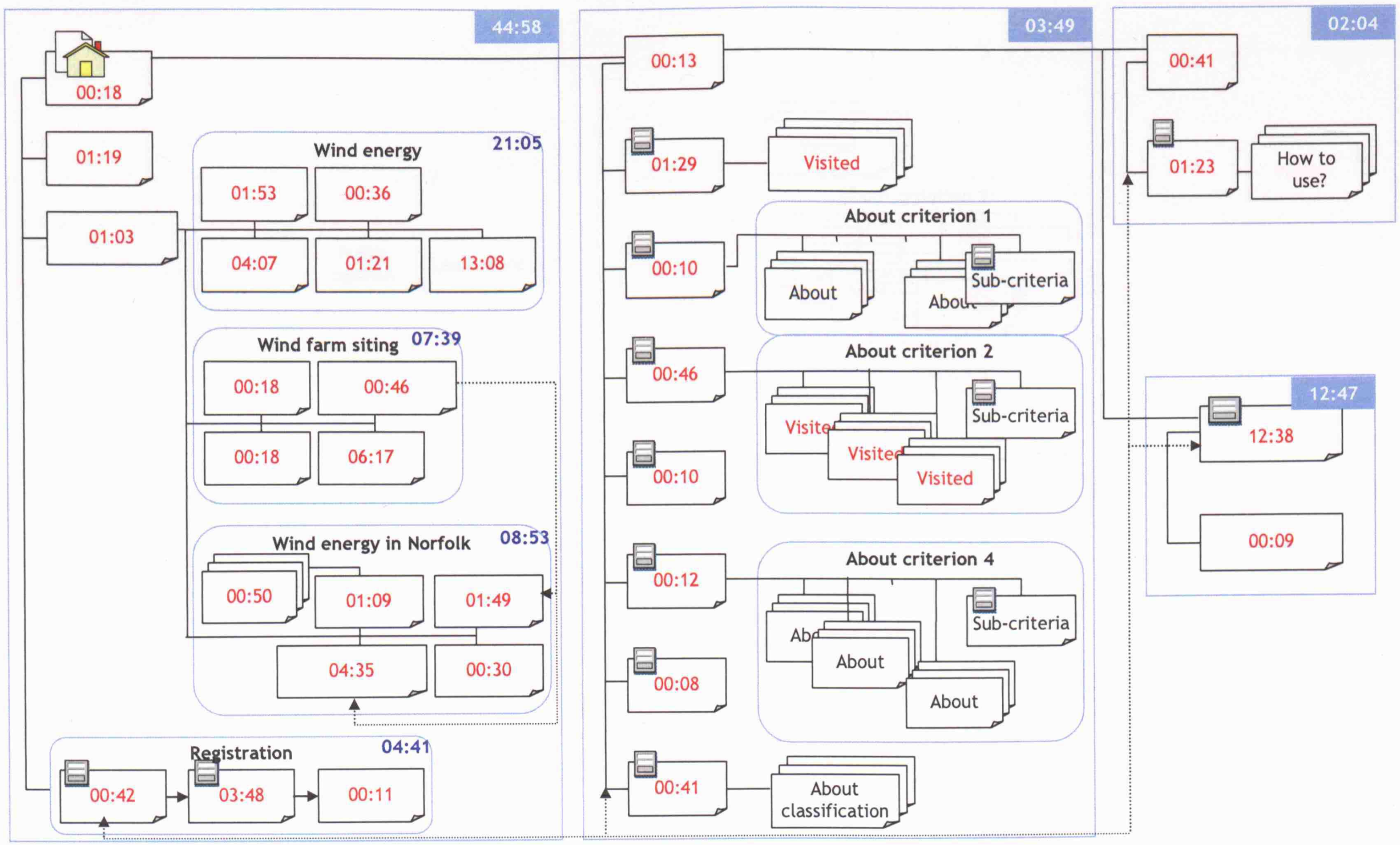


Figure B.16 - Details of Participant 15's usage of WePWEP.

Total time in the system: 01:14:53

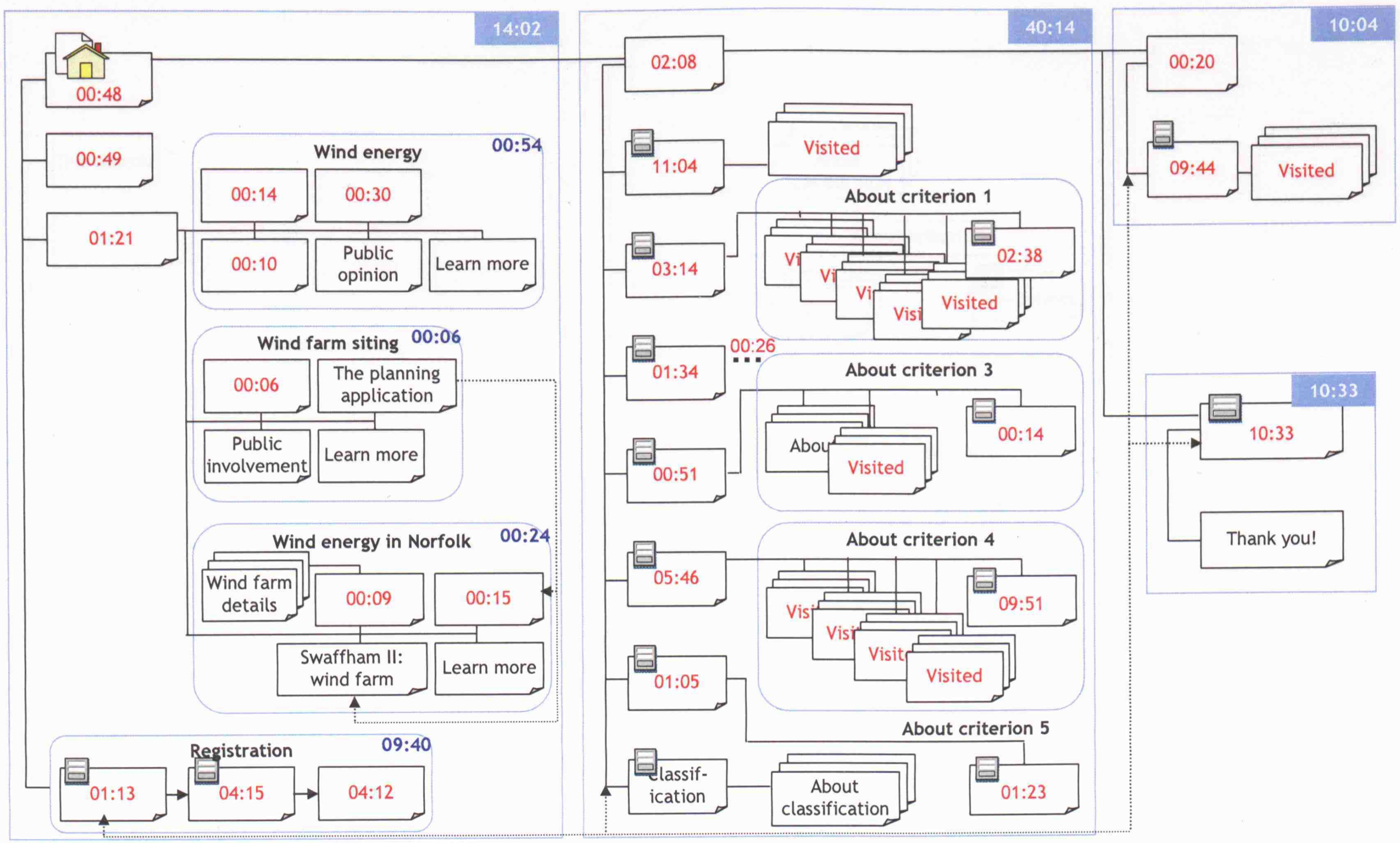


Figure B.17 - Details of Participant 16's usage of WePWEP.

Total time in the system: 00:57:35

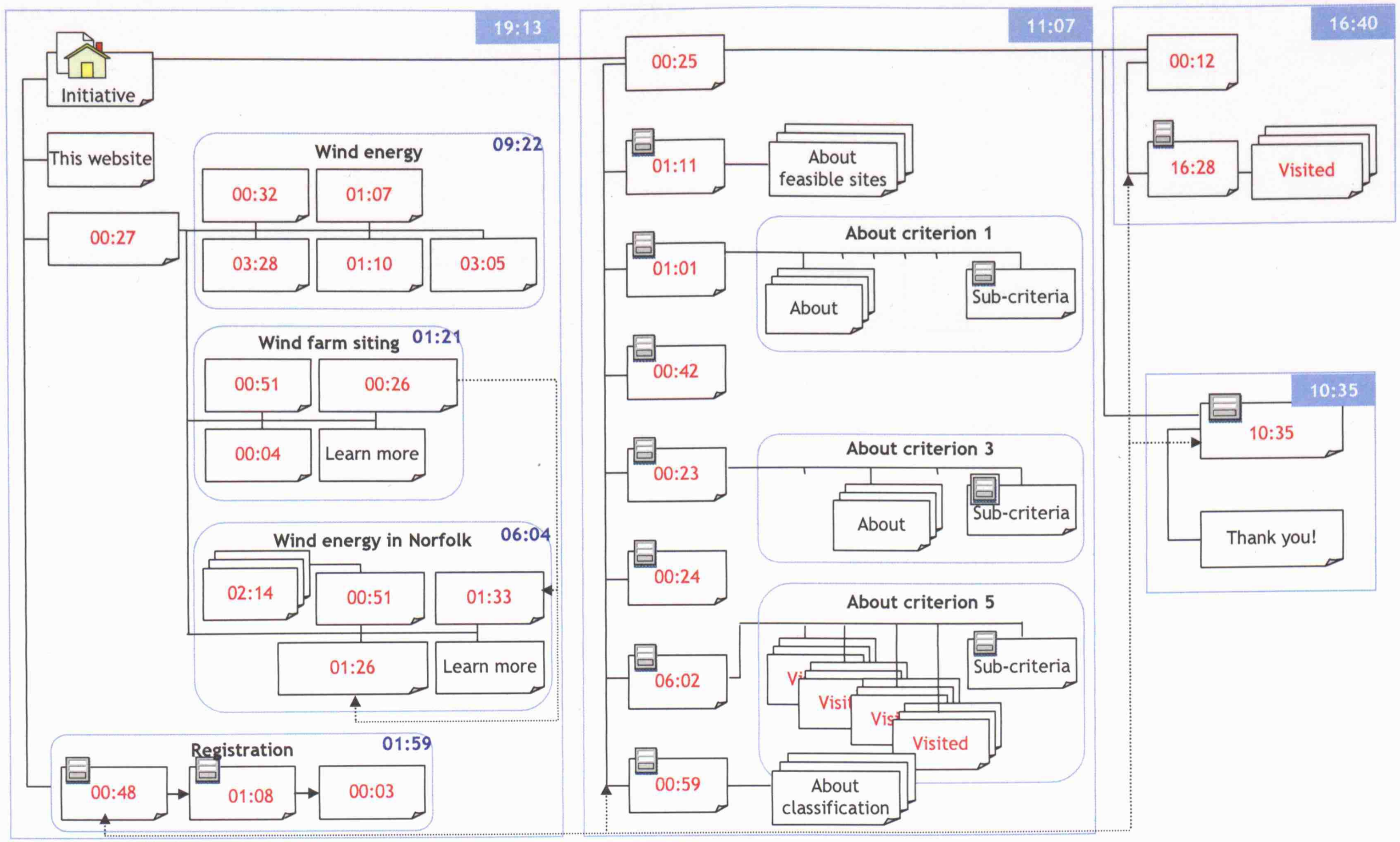


Figure B.18 - Details of Participant 17's usage of WePWEP.

Total time in the system: 00:59:21

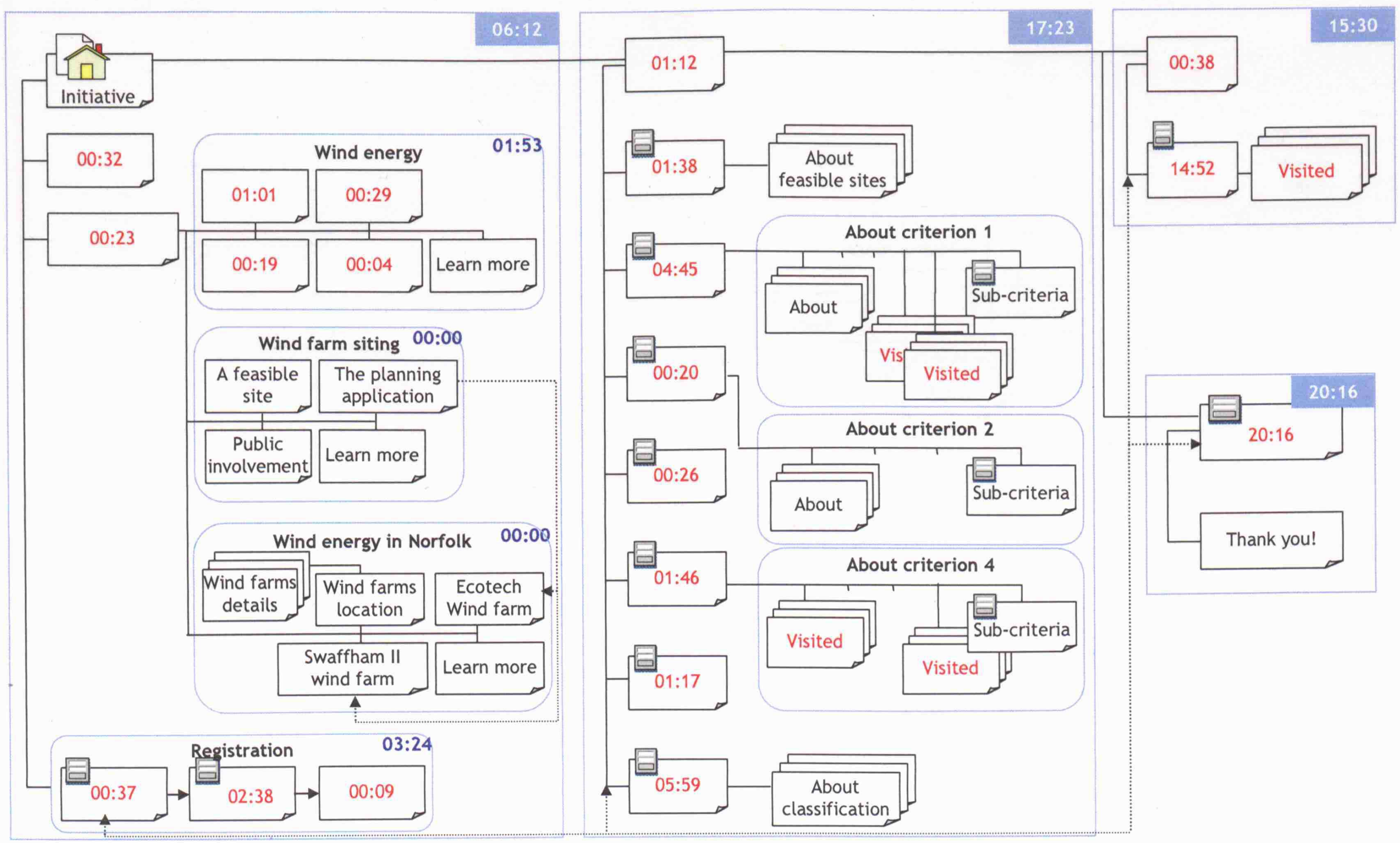


Figure B.19 - Details of Participant 18's usage of WePWEP.

Total time in the system: 01:39:49

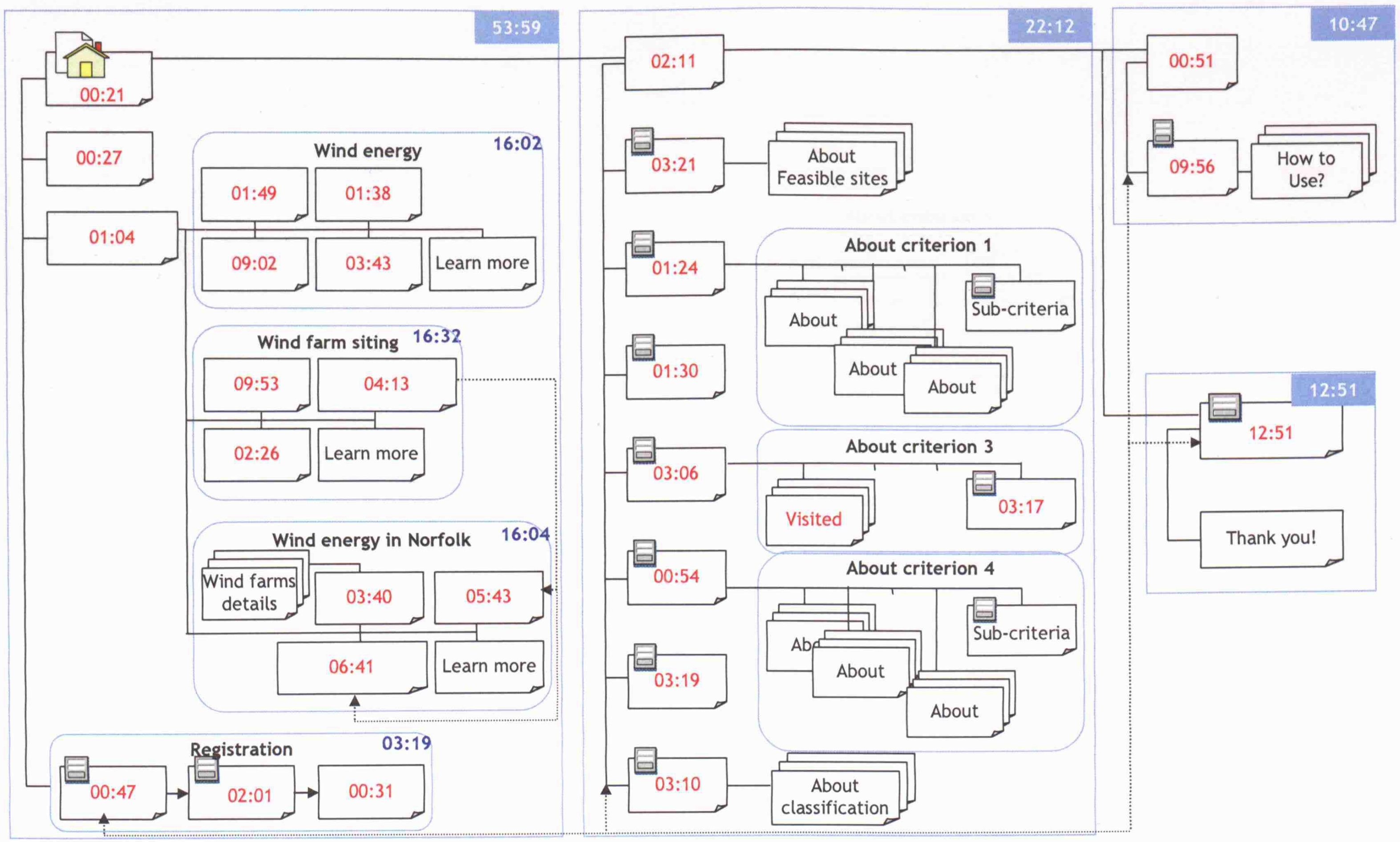


Figure B.20 - Details of Participant 19’s usage of WePWEP.

Total time in the system: 01:14:37

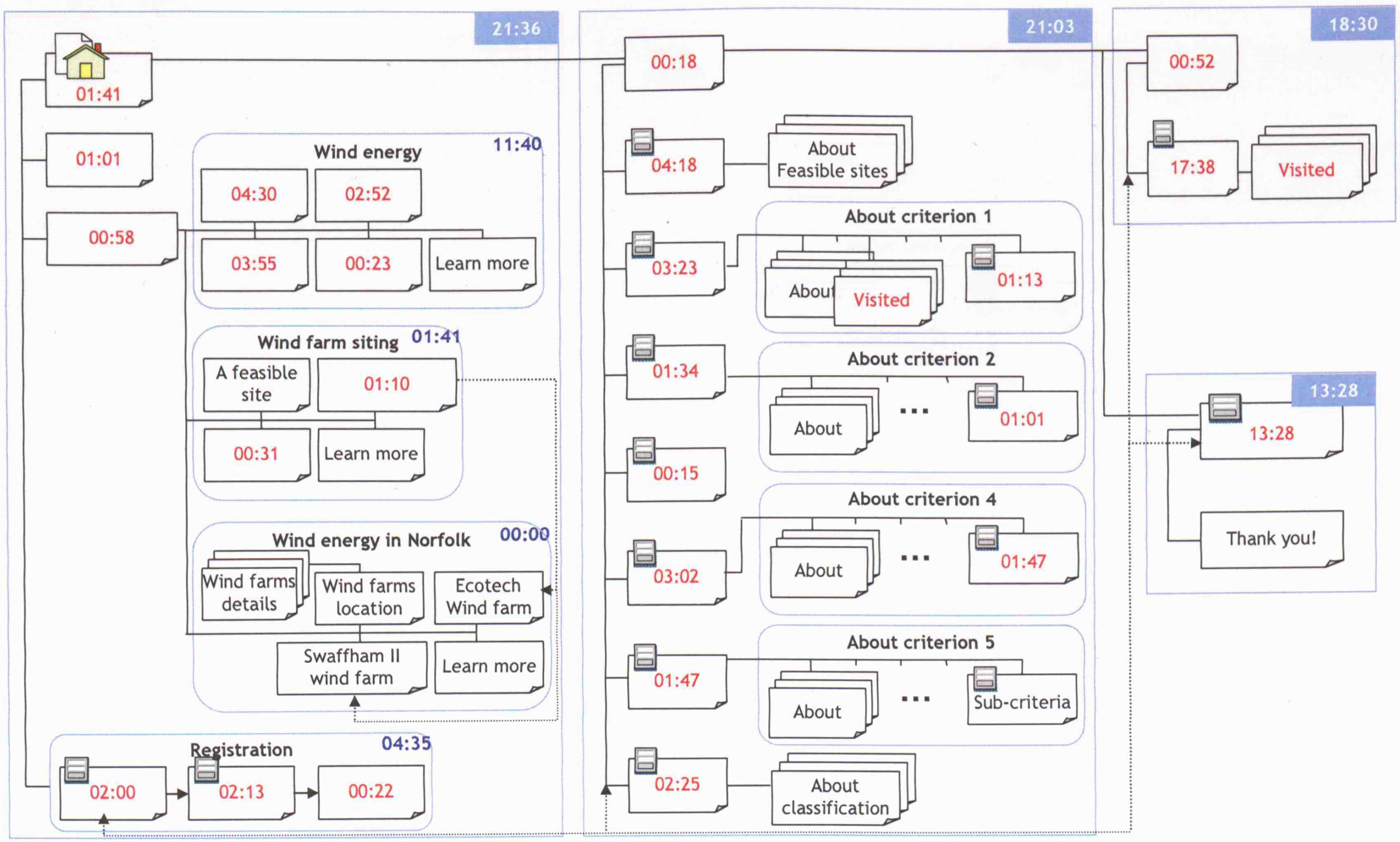


Figure B.21 - Details of Participant 20's usage of WePWEP.

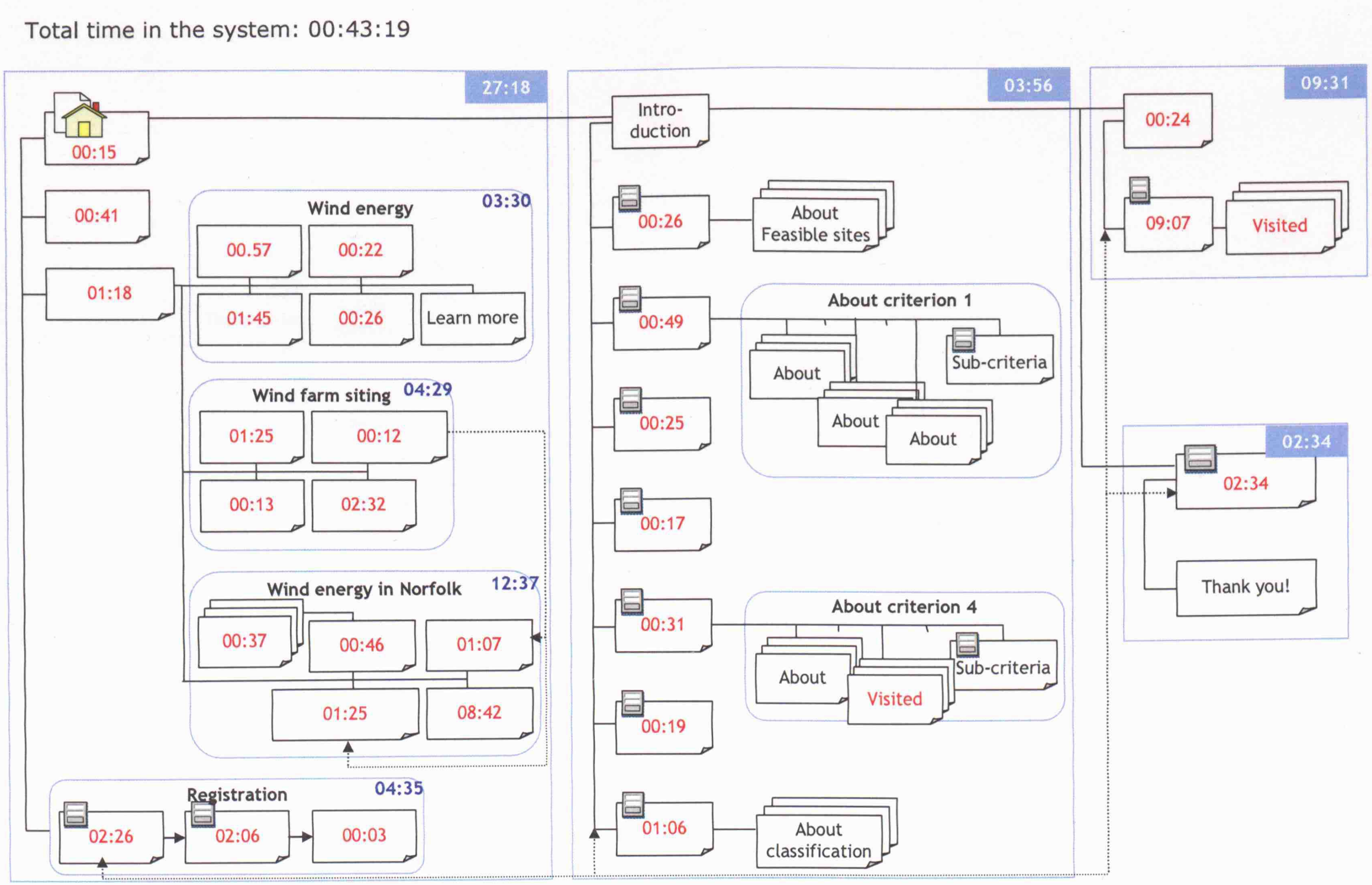


Figure B.22 - Details of Participant 21's usage of WePWEP.

Total time in the system: 01:08:18

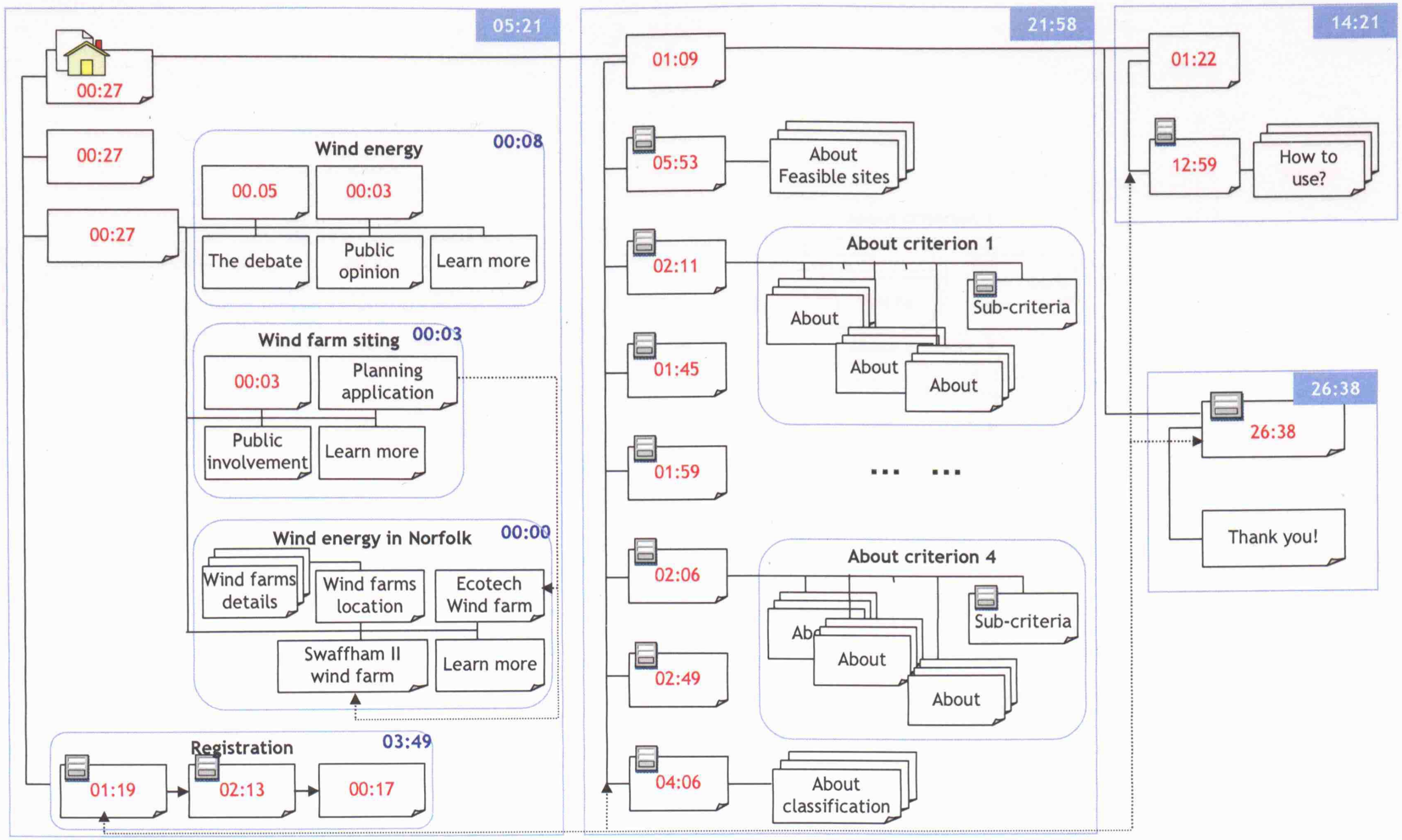


Figure B.23 - Details of Participant 22's usage of WePWEP.

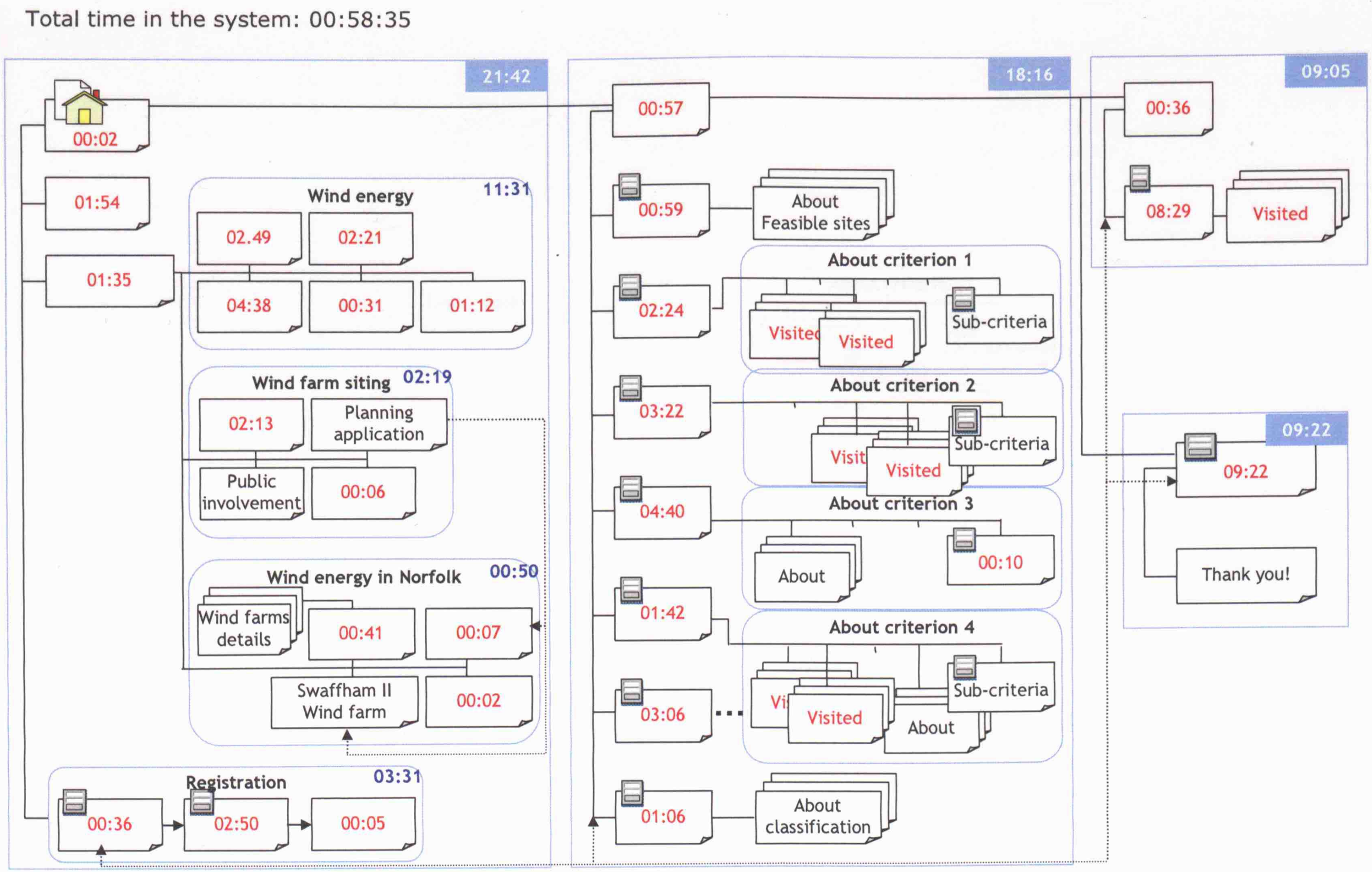


Figure B.24 - Details of Participant 23's usage of WePWEP.

Total time in the system: 00:57:44

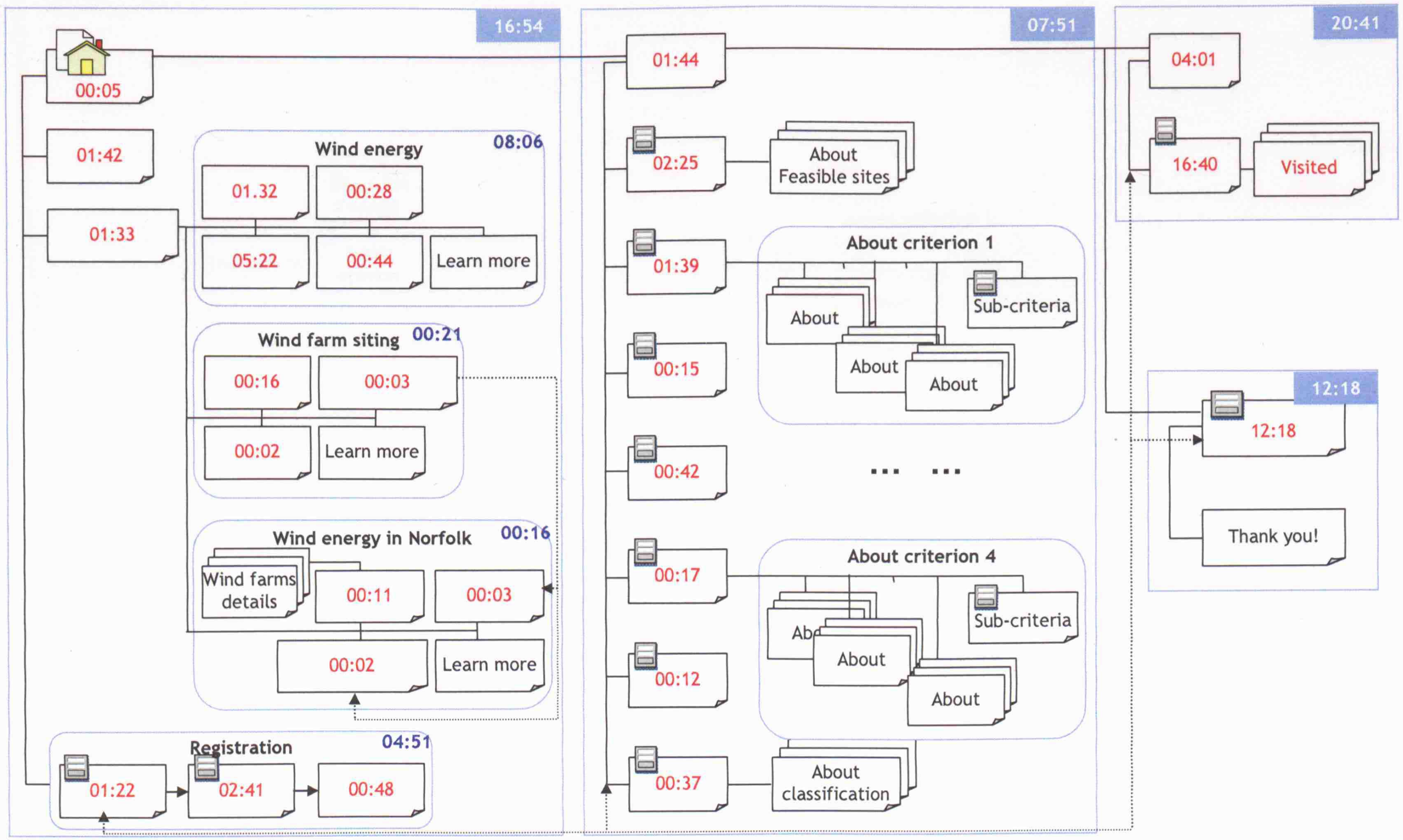


Figure B.25 - Details of Participant 24's usage of WePWEP.

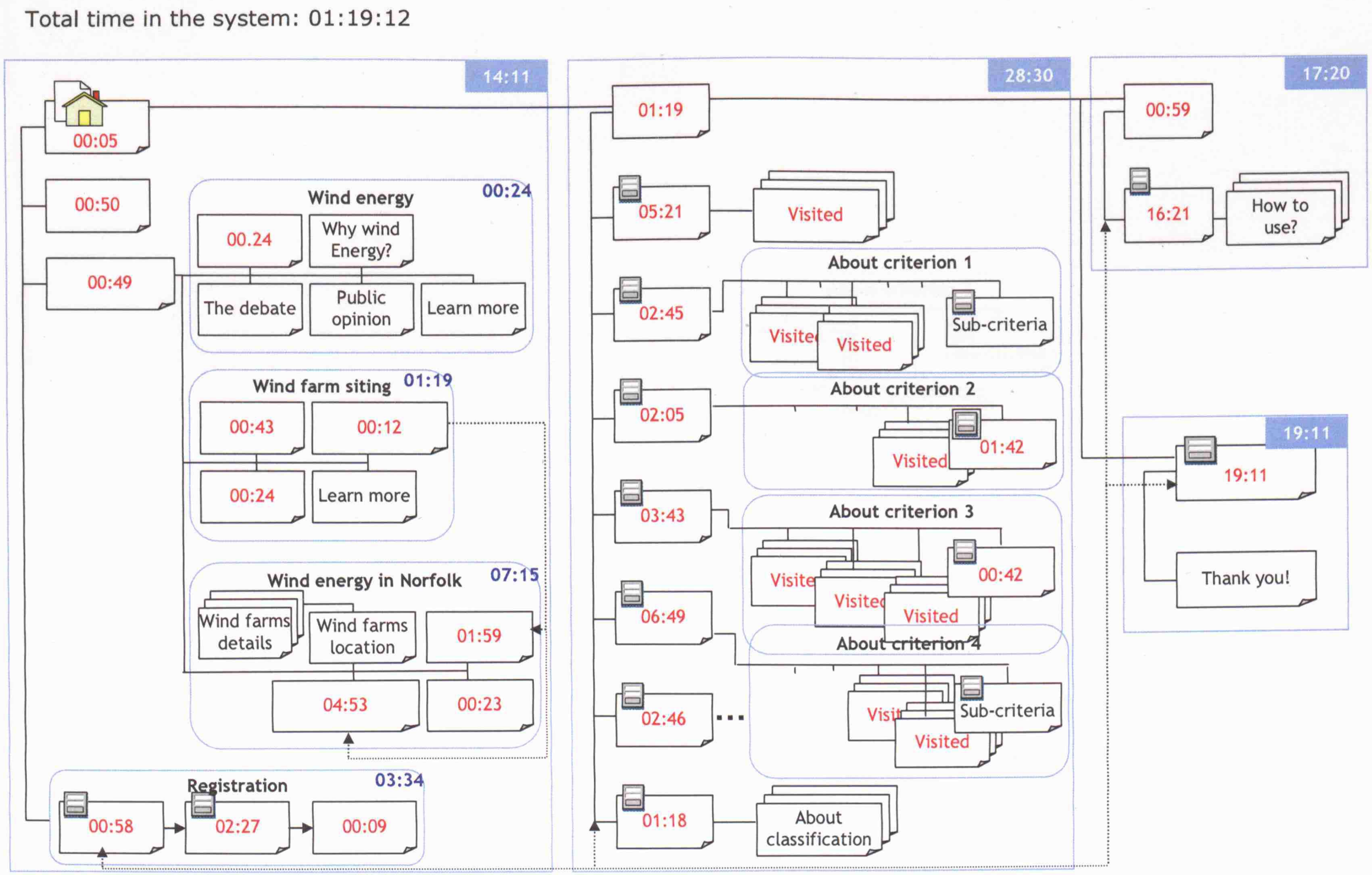


Figure B.26 - Details of Participant 25's usage of WePWEP.

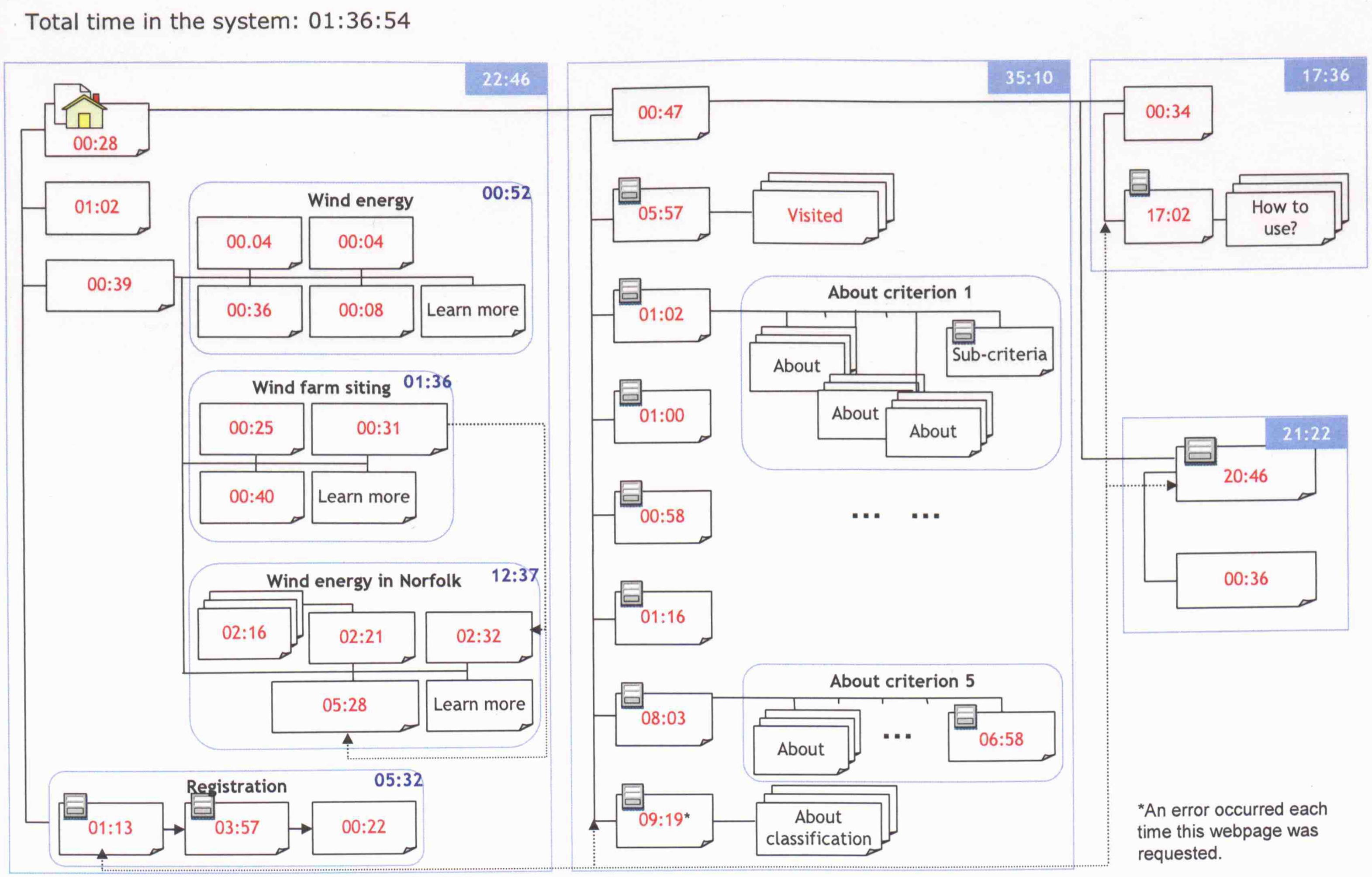


Figure B.27 - Details of Participant 26's usage of WePWEP.

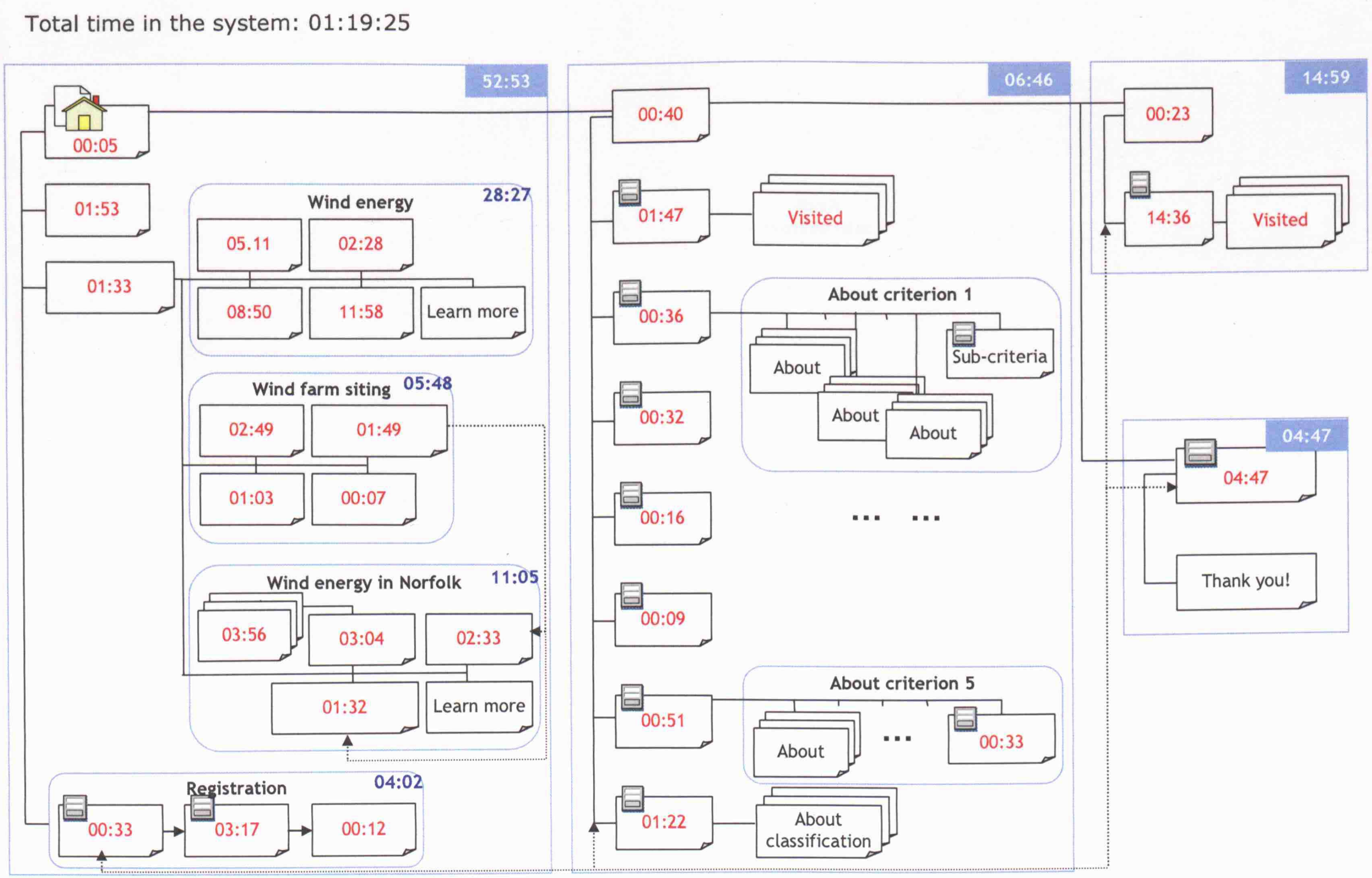


Figure B.28 - Details of Participant 27's usage of WePWEP.

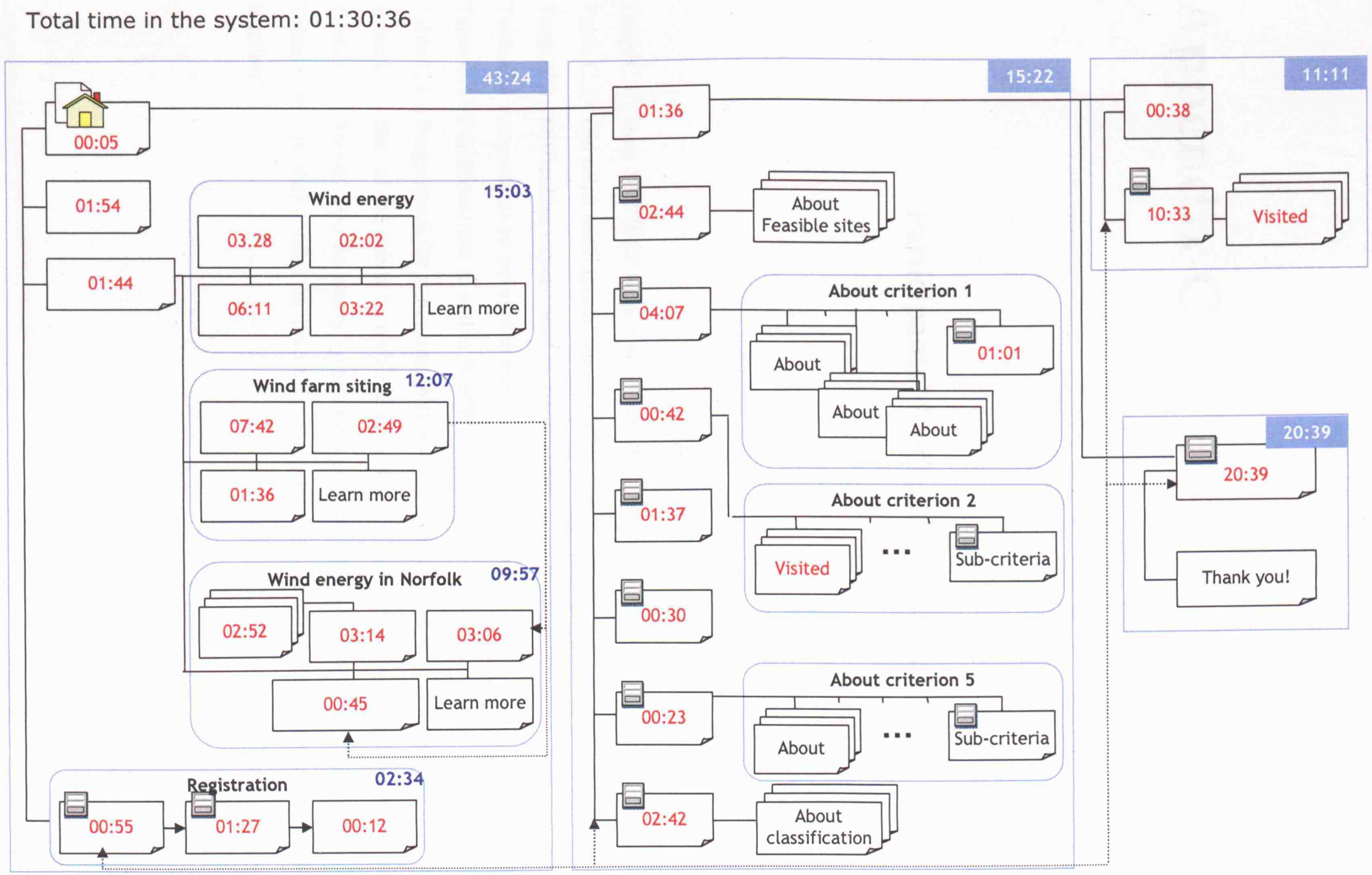


Figure B.29 – Details of Participant 28’s usage of WePWEP.

Appendix C

Participants' feedback on WePWEP

Table C.1 - How WePWEP helped you learn about wind farm planning?

Participant ID	Please specify how this website helped you learn about wind farm planning
1	Show me the many issues that need to be taken into account. The information is very detailed and the overall concept of the site, the headings and the organization of how the info is delivered is good, in a logical way. The more you read the info the better you could 'play' with the interactive maps to choose the suitable sites.
2	It is a complex website with a lot of information and technically challenging to navigate. The initial information sheets were very useful; I also learnt from the multicriteria weighting but got a bit lost at the point of discussion.
3	I did not know there were so many issues involved in planning (such as site remoteness, safety, etc.).
4	It made me more aware of the various issues surrounding the locations of wind farms, for example, I was not aware of electromagnetic interference or the blades affecting the lighting. The creation of a proposal section was particularly useful.
6	The information in the introduction about the planning process, who is responsible for what etc, and the order in which things happen was valuable. Seeing examples of planning process and how developers attempted a dialogue with the stakeholders was reassuring and it was interesting to see how objections were lodge late (e.g., MoD about Swaffham). Given knowledge from introduction, many objections seem strange - e.g., 'flicker effect' would seem to have been hugely overstated.
7	Clear presentation of benefits and disadvantages of move towards wind farms.
8	Didn't know about all the aspects that are considered during the planning stage
9	More understanding of the different criteria which are taken into consideration when choosing sites
10	Explained the planning application procedure.
12	There was lots of detailed information which made me think about issues I had not considered before.
13	It highlights the many different areas that influence windfarm planning. It makes clear what needs to be taken into account and contains a vast source of knowledge on wind turbines.
14	Clearly is a valuable resource, I would expect to learn much more if I spent more time with it. Interesting to see the spatial distribution of wind farms that are running and those that have been rejected and why.
15	There were lots of supported information and plenty of links to other sites to add differing arguments and opinions.
16	I found myself giving factors the 'most important' ranking and then thinking that the ones I hadn't chosen were equally important....it made me realise that the decisions are not easy. I want renewables, but not in beautiful places.

17	Lots of facts and figures.
18	I approached this website with a high degree, relatively, of knowledge of the issues so didn't find it particularly informative. If approaching with no knowledge of subject probably would have found it very informative of the process
19	I had already researched into the planning of wind farms, but this site would have been very useful before I had done this as it has valuable information, and the real life planning procedures are well presented and easy to read. The discussion section was a new facility to me, as was determining possible sites in this area.
20	By providing links to official websites and research.
21	The information and hard data provided.
22	I knew about wind farm planning from taking a course in renewable energy 3 years ago so I was already aware of planning issues. With the short space of time that we had to look at the website I didn't have a chance to look at the introduction to the issues (hence I ticked the box - learnt nothing for question 1). The maps are good visualise areas that are suitable for wind farms and I think they'd help the general public to understand why wind farms cannot be built anywhere.
24	I knew that there are many positive sides about wind energy. However I was not aware of many negative sides and I feel that I know more about them now.
25	The website gave a good introduction into the complexity of balancing competing forces in the siting of windfarms. I think though that less importance should be attached to local views in the planning process, and at present it seems to be a large part.
26	The first section provides a lot of information. The second section was a good way of showing the information from the first section in an interactive and graphic way that will engage people and make them think about what affects the location of wind turbines.
27	It was interesting to see the points where the public can express their opinions. It was also interesting to see some of these opinions in the discussion forums, to see the sort of opposition that plans would get.
28	The introduction has a lot of information on wind farm planning - this is a good starting point as you can just read it and absorb it! Actually being able to weight different criteria yourself and discuss it is a very good way of learning as well, because it makes you think about the issues that are considered in wind farm planning.

Table C.2 – Did other participants' views influence your views?

Participant ID	Did the information provided by other participants (by means of the "social" and "controversy" maps) influence your views?
1	Didn't see those maps, but as at the end of the day, electrical energy is to improve life quality, the opinion of other people about how this things affect their life quality needs to be considered.
5	The forum is useful as it allows an easy means to ask questions and so answers from the developers
6	Only very little. Knowledge of the facts had far more influence on me than knowledge of people's opinions. Controversy was possibly more interesting than social.
11	Didn't get that far!
12	I unfortunately did not get on to this part as the page took a very long time to load.
13	It is vital to learn the opinions of the people who are actually affected by windfarms. As I do not live near a windfarm the views of people who are directly affected by them are definitely influential.
16	Not really because I didn't have enough time to look properly.
17	I thought I was very pro-wind farms until I saw the controversy map / social and realised that they had more suitable sitings than me! I did try to go back and alter my answers but I found that the website had crashed and logged me out (it did this several times in my session)
23	Some opinions from local people.
28	Yes, I would say that ecological considerations are a priority criteria, but through the forums you can see how people's day to day life can be affected by wind farms and this does change your views.

Table C.3 – Difficulties experienced by participants.

Participant ID	Please give details of any difficulties:
1	Took me a while to understand how to contribute an interact with the maps, the rankings of the impacts (thought they have to add up to 100), how I can develop my proposal, don't know if I skipped some info, but may be an intro of how to built up/interact with the maps (i.e. that you will be using the info of the maps to rank the importance, etc...) The other thing I found difficult is to keep in mind the outcomes of the other maps like the distribution of the reserves or bird-important sites, it may be some criteria that don't really matter as any way there is no enough wind there. Having the wind speed map displayed all the time, (don't need to be interactive) would be helpful.
2	There was a lot of information to consider. I wonder if being guided through the website as a group by a moderator would make it easier to navigate and consider. It would also be useful to see how different age groups would use it. It contains a lot of technical information and terminology.
3	Slightly difficult to use and understand reference tools in map layers. A bit difficult to understand map layers section.
4	Having not used discussion forums before, I was unaware that double-clicking on the triangle icon would allow me to see the rest of the thread, and the map layers were a little confusing to begin with.
5	Some of the criteria seemed overlap somewhat, it is difficult to distinguish visual impact form impact on the landscape. I would imagine that those who do not usually use a computer would find it difficult to navigate. Reading large chunks of text can be tiring onscreen and moving between sections was a little tricky. Perhaps, in addition or instead, the text should be provided in booklet form. I found it far easier to take onboard the info from the PDF file that I printed before the session than from the site itself. If this system is to be used for public consultation it must not be used on its own.
6	Layers on the map do not seem to be in a logical order - I would expect to see locations of existing turbines and ones that have been accepted or turned down layered on top of social opinions of areas, for example. Was hard to know what criteria were based on - was it purely visual intrusion, was noise taken account of, did it include physical factors such as distance from roads and dwellings?
8	Maybe needs a few instructions of how to use maps
9	Not immediately clear what is being shown on the maps i.e. which layer is visible when several are ticked. Also not clear how to get the OS map to show underneath. Not immediately clear where to go to do the sub-criteria weighting.
10	Sometimes a little unclear due to not seeing the whole process. At the end I wasn't sure how much difference my weightings made.
11	Legends need to be simplified for common usage - remove some of the legend detail. Own classification for feasible sites seems very complicated.
12	The page took too long to load.

14	Overall very useful, but found the menu a little clumped and small on the side of the screen, but understand the design factors that have to be considered with screen size. Overall it does take a little getting your head around, but once that is achieved, this is very interesting.
15	I don't remember seeing where I could enter my own classification for feasible sites nor where I could enter a contribution. I might go back at a later stage and take a look, because I would like to offer an opinion.
16	Perhaps having some continue buttons on the bottom of the screens were I was creating the proposal would have been helpful. It wasn't really obvious how to get to the screen where the weightings of the sub-criteria were situated.
17	I think people with less experience of using GIS would find this website incredibly difficult to use. There are some great features, but it needed the moderator to keep coming over to explain them. When using a website, people need it to be user friendly - if it is too wordy, or too complicated, they simply won't bother (although maybe I am wrong in the case of potential windfarm sitings being near your own home - could make you more concerned?). It would be good if instead of constantly having to go over to the help, there were pop-up boxes you could click on to suggest different ways to view your map, for example.
18	The classification issues were fairly complex, possibly by necessity, without the aid of background knowledge would have found it fairly difficult to comprehend the weightings etc in order to use the classification to express my views.
20	Sometimes trawling through lists of facts to get to the one of the link was a problem. too many factoids sometimes. Easy to register but not obvious how to get into pages. Not obvious how to create your own weighting in your own classification section. Website works well if you go through it in order, but each section is not self-explanatory otherwise. It would be easier if the 4 main section headings always appeared to scroll back to and if the site 'autoreturned' and updated on changing weights. Also would be good if already-used links changed colour.
22	I found the items that I ticked a bit complicated to but I think this is mostly due to the time pressure i.e. half an hour on the website was not enough to fully understand all what the website can offer
23	It took long time to load the map and it was difficult to use it
24	It looked bit complicated. Also I needed to open another window to read the explanation.
25	I didn't grasp the hierarchical nature of layers at first. The text of the website could be made clearer. Legal terms like 'adduced' in the summary of one of the planning processes could be replaced by a clearer alternative. The text could be simplified in a number of places. I think this would be important to make the site more understandable to more people.
26	I found the maps ok to use but I could see that anyone not used to using these sorts of maps could find them difficult to learn how to use them. When I tried to create my classification it set all areas as unacceptable. I was told this was an isolated error so would not normally be a problem.

27	I have not had much practice in using this type of map, so it was a little confusing, although I'm sure that if I had spent more time playing around with it I would have got the hang of it better.
28	There are no real problems, but I am familiar with this kind of thing. There is a lot of information for a member of the general public to absorb here, and I think that they might find the layout of the map and forum a little difficult to get used to.

Table C.4 – Aspects to be covered in more detail in WePWEP.

Participant ID	Is there any issue, aspect or information that you would like to see covered in more detail in this website?
1	A summary of the impacts of the other types of plants, because at the end of the day, whether or not choose for it should be in respect with the costs of the others, like air pollution, water waste, etc.
2	How the information provided through this exercise would feed into a consultation process.
4	More public opinions, case studies and direct cases where the public have been influenced by wind farm siting.
5	Many peoples' reservations about wind farm use is that they are uncertain about whether it really is the best way forward to meet our CO_2 emissions and provide energy for the future. Whilst this is somewhat out of the scope of this site this perception will affect opinion on site.
6	Did not state difference between large and small wind farms or if this referred to turbine size or number of turbines. Location of churches, historical monuments and similar would affect my personal opinion on location.
7	However, context as part of a mixed energy portfolio was not present/evident in information provided. Neither did I note an indication of the number of households/domestic users of electricity in the UK as a base-line for interpreting the number of households which could be supported by wind turbines - i.e. quantification of volume.
8	The energy which would be provided by the windfarms. and how much this new renewable energy would impact on the non renewable energy, would we even need any if we had enough wind farms etc.
9	Not sure as didn't get a chance to explore fully. In relation to the background info provided in the emailed document, statistics about how much power wind turbines provide need to be made clearer. Definitions of things like kWh should be given (not sure if they are on the website).
11	All relevant information seems to be included - sometimes too much.
12	How the public could get involved in the process of wind farm siting.
14	Maybe I didn't spend enough time looking at the site, but there are clearly assumptions made in the choice of factors and the potential for error and uncertainty, I am not sure how clearly these are illustrated, but then again this further complicates the site.
15	I would like to have seen more public information. Government and formal information will always be biased towards what the organisation is trying to achieve. I would like to have information from the people living close by who are affected by the wind farms - not all local people think that additional tourism is a good thing.
16	An indication of how many wind turbines we'd need to achieve the 2020 goal of 20% production from renewables....how many and where and how big and some photos of what all the pretty areas of the UK might look like.

18	Many of the discussion posts expressed opinions on the visual impact of turbines in terms of how they rose above the horizon.
19	A little more about the current wind turbine industry, i.e. the developing off-shore industry.
20	More official policy links.
23	I think it should include data about demographic
25	How much government subsidy to windfarm builders is recovered?
28	How much CO_2 do wind farms actually save? They must produce a lot of CO2 in the production phase, do the recover that in their lifetime? Do they cause the inefficient running of conventional power plants as they are powered up and down to compensate for low and high wind conditions?

Table C.5 – Functionalities to add to WePWEP.

Participant ID	Is there any functionality that you would like to have available in this website?
2	Making the legends related to the maps clearer to see and use. In some cases I was lazy and didn't read all the background material which would have helped me figure out how some layers are represented, e.g. overlaid.
3	Would be good to have more people involved on website. Hopefully that will happen in the future.
6	Would be nice to have at least some degree of photographs of the sites that could be accessed from the map - interactive photos of an area with or without turbines, or with different number of turbines perhaps
7	When you have followed a hyperlink to explore more information - an option to take you back to the section you were originally in would be useful. For example, hyperlink to 'two real-world illustrations'.
9	Don't know if this is on there, but testimonies from people who live near sites.
11	A postcode finder so that residents can see in detail their local area.
13	The area of map for classification and discussion expanded to the whole of East Anglia. So users can identify and examine the areas where they live - thus, providing a more interested and knowledgeable response.
15	I would have liked it to be more interactive - I did get a bit bored, and probably wouldn't have stayed on the site for so long if I hadn't been part of the experiment.
17	Pop-up boxes, as explained above? A far less complicated outlook.
18	Many of the discussion posts expressed opinions on the visual impact of turbines in terms of how they rose above the horizon. The maps given are all 2D, perhaps some idea of the topography and visibility of a turbine could be given as a separate layer.
19	Links to related sites, such as BWEA, manufacturers of wind turbines (Vistas) Government white paper, PPG 22.
23	The helping section should be reviewed.

Table C.6 – Suggestions for enhancing WePWEP or consider in future applications.

Participant ID	Do you have any other comment, suggestion or thoughts that you would like us to consider in further developments or applications of this system?
2	I think it has to be made a bit simpler for the 'ordinary' person to be able to use it adequately. With so much information the risk is information overload which may lead people to answer questions without having really thought them through, thus introducing misleading responses.
3	The only part that I found difficult to use was the map layer section. Other than those difficulties, it's a useful website.
4	Maybe slightly more information on how to use the maps and discussion forums.
5	A website that takes a fairly long time to go through isn't really a problem. If the user has an interest (such as proposed site near their home) they will not mind using the time.
6	I felt that it was a little unclear as to exactly what the outcome of the exercise was meant to be. The information in the 'how to use this website' section was relatively clear, but some of the commands on the map seemed quite complicated. For someone with no experience of layering of maps I feel that it could be quite difficult to use. It was not so much a lack of information that appeared to be a problem as not really being sure what I was trying to achieve - perhaps a brief introductory statement about what was about to be done would have been useful.
9	The wording is far too academic. At present it would attract and be accessible for only a very limited audience. Whilst I as a very interested party would happily spend that amount of time reading and weighting different elements, to attract wider participation there could be different levels of engagement and classification offered perhaps. Instructions need to be clearer - where things are becomes apparent through clicking on underlined words, but things could be missed by people without the time or patience to look thoroughly at each one. Whilst it is good that you can flick between pages without information being lost, it would be better if instructions lead you through each step rather than relying on you exploring for yourself.
10	It was really very detailed; I'd be surprised if people would get through the whole site. Using the 'next' buttons makes it feel as if you must read everything and this can seem oppressive.
11	Simplify!!
13	There is a huge array of information on the web-site, this is of course a great thing. It is reasonably easy to access specific information you are trying to find. I am unsure of the use of the 'next' feature to go to the next page in the background section, the level of information was quite hard to digest. I think you need quite a lot of time to explore and 'get to grips' with the website, not necessarily a bad thing.
14	This is a very useful resource, I personally found it very useful, how it is applied it the participatory process will be a critical factor, I am concerned about the technical level that would be required to fully engage with this web site, it may exclude many from participating...

15	I think you need to lead people more into the areas that you would like people to look at, the web pages need to be more interesting - they were very wordy, and it should be more interactive to keep people involved.
16	Maybe it might be a bit less detailed... the site is very interactive and this is both a good and a bad thing... there was a lot of information and some quite difficult things to do.
17	I definitely think they website has a lot of useful information, and a great interactive planning feature. However, I think it is far too complicated for a member of the public to dip into for a brief time (which is probably all they would do). I also think the facts and figures info at the start should be made far more interactive - lists of words just won't be read! How about some pictures? Case studies? The references are good, but I'm not convinced the layperson would bother to go into them. Perhaps a short explanation could pop up if you click on the reference, with 'more info here' if they want to go to the full document? For example, a pop-up box could give a brief explanation of the document in question: who wrote it, for whom, and the main findings.
18	Using the site does take some time but that is a reflection of the complexity of the issues.
20	In some informing sections it would be better to be punchier and get the crux of the point out first: people get bored very quickly and can't always be bothered getting to an important bit. The font is too small. It is very easy to submit your comments!
22	I think you need a good couple of hours to properly look at this website which is perhaps too long for the general public. Also at the start when you had to rate what factor you found more important, I'd changed my mind completely the second time round. In my opinion I think it would have been useful to read all about the factors on the same page rather than clicking on each one to find more about them because it would be easier to rate them in the order of importance (you wouldn't have to keep clicking back to remind yourself what each factor was)
23	The layout of the map should be more unambiguous
24	I think public needs to be involved a lot on these projects. Especially people who live around the wind farm
25	I think simplifying and streamlining the participants interaction would mean the reach of the message would be greater.
26	I found it quite easy to use but I am very confident with computers and the internet. I think others could have difficulty unless there was some kind of walk through to guide them through sections of the site that cause them problems.
27	I think that some more photos of some of the sites might be useful, as a lot of the comments are about the visual aspect. I thought the site had a lot of interesting background information on wind energy, and the process of getting a site approved, as I am sure that much of the public don't know much about this process. I thought that the maps were quite complex, but this meant that they did hold a lot of visual information. I liked the section where I rated the different criteria, as it made me think about what I thought was important, and it was interesting to see how many areas I thought would be suitable for wind farms.

28	This is a great site! It is very in depth and that is excellent, but you have to remember it will be too much for the casual browser, they probably will not give it their time. I suggest a short, snappy front page to grab the interest of casual browsers. This will also give the '5 minute person' something to think about - and hopefully they might come back. There is loads of help available on this site, I would say that anyone who wants to find out how it works will have no problems using it! Well done though, overall, excellent!

Table C.7 – Should the public be involved in decision-making about wind farm siting?

Participant ID	Should the public be given the opportunity to be involved in the decision-making process concerning wind farm siting?
1	But not a lot. Is the job of the experts, but feed back is always needed. More to consider if there is going to be any complaints but most importantly because if you have an involved society in general is best and they will be pushing for more environmental friendly energy.
2	Because it's a decision that affects them. They are already given the opportunity to be involved, as the Swaffham II case proved.
3	It is very important for the public (especially local communities) to be involved. It simply doesn't work if there are high-ranking government officials telling everyone what to do.
4	They are the people who have to live near the farms and own the surrounding land so are important stakeholders.
5	Public consultation needs to be part of any major planning process. At a higher level the public should be given greater education and ability to decide on their choice of power source. If it does really make sense to attempt to make a significant part of our energy from wind and this is clearly explained to the public I believe planning and siting of turbines will be much easier and will pass with little resentment.
6	If people are left out of the decision making process, this WILL have a negative effect on their opinion of wind turbines and this could feed through to other environmental issues.
7	If there is a large-scale move towards wind farms, the amount of acreage required will be vast. Therefore, there is the potential for a greater shift towards regarding them as a blot on the landscape.
8	They would just be concerned about seeing one from their house and not thinking about the environment
9	Will foster acceptance in the community if people are engaged in the whole process; think it should be in the context of an evolving dialogue where concerns and any misconceptions can be addressed.
10	The local public are stakeholders who have to live with the decisions daily.
12	Because then people will be better informed and more likely to agree with the idea. They should be allowed to have a say in their future.
13	Because it is an area of great concern with large impacts on the local environment.
14	Particularly those that live in the local area, or who visit often, it is important in a democratic society that public participation be an important part of the process.
15	I think that public opinion is very important, but my understanding is that the public have the chance to have their say at forums.
16	There input is important but not overriding. Being involved in the decision making process informs and educates and this is as important as anything else.

17	Definitely. The more participation they have, the more likely they are to be in favour of the decision made.
18	We have a democratic process that needs to be seen to be followed: however the debate/public inclusion should be on where to site for each given settlement and not whether to site.
19	They are already involved, and this makes them feel important and involved. They can also raise issues and become more aware of wind farms, and their opinions may become more positive.
20	But as a yes or no to a site proposed in terms of power-efficiency.
21	To allow them to air their views and understand the 'big picture'
22	I think if the public is involved in the planning process they might not be so opposed to the siting of wind farms. Also if they are educated why it is essential that we have sources of renewable energy, e.g. wind power, they might be more accepting
24	Especially who lives near the wind farm or who are going to have wind farm near his or her house.
25	It depends on how much electricity the windfarm is likely to produce - if there is lots going for a particular site e.g. it is in a windy area, with good access, close to an appropriate energy consumption centre, then the public input is less important than if the site is marginal.
26	The public should learn about the limitations for siting wind farms so that they can make more informed decisions with respect to their views on the development of wind power in the UK.
27	I think they should to an extent, as obviously having a wind turbine being built in the vicinity will affect them. I think they should have the opportunity to bring up there problems and complaints, or their support, so that the authorities take these into account when deciding whether to allow planning permission. I don't think the public should actually have a say in the final decision though.
28	Definitely. We have to move towards projects such as wind farms in the future and for them to become widespread, they will have to have public support. It is vital that the public get a say in where they are placed, they will never thrive if they are unpopular.

Table C.8 – Should a participatory system both provide information and collect input?

Participant ID	Should a public participation system be solely concerned with collecting participants' thoughts, without seeking to inform?
1	See previous paragraph, the quality of thoughts will be related to the quality of info the 'thinker' has. Other wise would be only gut feelings.
2	Yes and no. The thought collection process is different to one that also seeks to inform, so it depends what the ultimate aim is.
3	They need to know the background of the topic.
4	The public need to be aware of all the issues in order to make an informed decision.
5	Informed decisions are vital and there is little point in asking people who do not understand the issues. However it can be difficult to get a balanced view on the issues. The background info cited information about the max power from turbines but little about how often this was available. Wind power is still technically primitive and it not at a stage where it can become a major part of the UK's energy supply.
6	People are very likely to change their belief when they are told a correct piece of information, for example many people believe turbines are noisy whereas modern turbines produce very little noise; and people's opinion have often been formed by negative press on turbines such as newspapers calling them ugly. Also if people believe that more energy is expended in building turbines that will produce in its lifetime, they may find other reasons to oppose it.
8	If they know the facts they are less likely to give a personal reply relating to their home.
9	As above - I think a lot of attitudes towards the siting of windfarms are formed without people having spent time near turbines, reflected in the fact that while there is much opposition to them being located close to communities, those communities that do have them become overwhelmingly in favour of them. There is also on minimal worth in thoughts founded on misconceptions - all participants should gain the maximum amount of info so as to make an informed judgement
10	Information is essential to make people think and to empathise with the final decision.
12	If people are better informed their opinions may be altered more in favour of wind turbines.
13	It is essential to educate participants. Although it is crucial that information is not biased.
14	There thoughts may change as a result of being better informed, it is important to stick the right balance
15	I think that people should be able to voice their opinion based on their knowledge, and then be given further information for clarity and to educate. I do think that education is vital to creating a more sustainable future, but ignorance is bliss. I worry a lot more about the effects of the fuels we use since I have become more aware of the issues.

16	Because they need to be informed properly before their thoughts are of value...other prejudice etc.
18	Issues, such as WE, are often surrounded in myth and controversial argument and counter argument. Without adequate, honest, information participants will only be able to express unrational opinions based on unsubstantiated emotional responses to issues.
19	it is important to inform the public, so they can learn the facts. They will then be more understanding to wind turbines instead of seeing them as an eyesore.
20	Perception is often more important than what is really happening in terms of social-wellbeing.
22	You have to inform people of the pro's and con's, all the facts and why we need wind farms so that people can make up their own mind on the technology.
25	It should always state the rationale for building windfarms, i.e. inform the participant: it would be dishonest to do otherwise!
26	People must be able to make informed choices. If you can provide information it could satisfy their queries so you only get useful thoughts.
27	People are not able to give useful comments and thoughts unless they are given appropriate information, so in the public participation process, reliable unbiased information should be easily available to the public.
28	Because as you learn new things, your views change!

Table C.9 – Is there value in involving the public in the strategic planning of wind farm location?

Participant ID	Do you think that there is value in involving the public in early stages of the planning procedure, when no specific planning applications are addressed (such as in the example used in this website)?
1	Yes, partially, people could address some things that the planners didn't think on consider, but after a while the contribution from the public will start to be redundant.
2	Getting people to participate in an exercise like this could raise expectations or demands from the planning process. One has to be very clear and honest in any situations involving the public.
3	As above, the public should be involved in the whole process, and should understand the issues.
4	If no location has yet been firmly decided the public cannot make valid feedback.
6	I believe this is essential as by entering dialogue with stakeholders plans can be fined tuned to avoid many potential concerns of stakeholders and so reduce, if not eliminate, objections to a scheme. It will make more of people happy if the scheme is granted permission.
9	May save developers time in avoiding very controversial sites and may open up new possibilities.
11	People become too involved before any suggestions are put forward thus complicating the planning issues.
12	The more people feel involved the more they will like the idea, as they will feel their input is valued.
13	As the impact can be so large early involvement from the public is crucial. I think people are more inclined to accept a plan if they are involved from the start, especially if they feel part of the procedure.
14	There does seem to be a tendency for people to feel more ownership and may have ideas to contribute to win-win solutions, it may head off objections in the long run.
15	I think people affected by any sort of process should be involved, even if it is to get buy in for the projects. People don't respond well to bullying or things being hidden from them. They should be aware so that they can educate themselves to the effects.
16	Because it helps people formulate their opinions BEFORE nimby'ism comes into play. And they after nimby'ism perhaps their opinions are better balanced
17	I think if more people knew, for example, the favourable reaction in Swaffham, windfarms would be more easily sited.
18	It creates a sense of empowerment and ownership necessary to achieving a good outcome.
19	So they can see that there are many sites that are suitable for wind turbines and that they have less of an impact to the environment than expected.

20	Pointless: a waste of time.
22	I think it is a good idea but I don't think the majority of the public would bother involving themselves in the planning procedure unless application for planning of a wind farm was happening near them
24	It is better to listen to the public from the early stages of planning procedure so that the planner can take in account of the public voice in any stages.
25	Although, it depends on the cost of involving the public. At this stage it is a useful medium for informing the public about the need for building renewable capacity.
26	It is useful for people to be able to find out general information so they know what the issues are important in any application that gets made.
27	I'm not sure that there is any real value in getting opinions if they are not specific to actual applications, but it is never a bad thing to find out more about the publics views.

Appendix D

Participations' contribution to wind energy planning

Table D.1 – Participants' weights of the evaluation criteria.

Participant ID	Visual impact		Local impact		Impact on ecology		Impact on landscape		Site characteristics	
	Weight 1	No. changes 1	Weight 2	No. changes 2	Weight 3	No. changes 3	Weight 4	No. changes 4	Weight 5	No. changes 5
1	20	0	30	1	100	0	20	0	12	0
2	20	1	70	0	50	0	10	0	100	0
3	70	1	83	1	100	1	75	1	82	1
4	20	4	40	4	30	4	40	4	100	4
5	30	6	65	7	50	5	30	5	100	5
6	-- Participant that has not registered. --									
7	70	5	90	4	93	4	100	4	52	5
8	70	0	45	0	100	0	70	0	90	0
9	20	1	80	1	90	2	80	2	100	1
10	85	3	65	4	100	3	70	4	70	4
11	65	0	15	1	65	0	25	0	100	0
12	10	0	50	0	100	0	50	0	80	0
13	--	--	--	--	100	0	--	--	--	--
14	62	1	68	1	100	1	54	1	83	1
15	--	--	--	--	--	--	--	--	--	--
16	90	1	69	0	97	0	100	0	86	0
17	0	1	75	1	50	1	25	1	100	1
18	10	1	20	1	40	1	60	1	100	1
19	100	2	80	2	60	2	40	2	70	2
20	8	1	25	1	22	1	22	2	100	1
21	50	0	50	0	50	0	50	0	100	0
22	40	6	100	5	30	6	70	6	70	6
23	69	3	52	1	100	1	87	2	66	1
24	59	1	100	1	34	1	25	1	34	1
25	30	0	30	1	25	0	60	0	100	0
26*	85	23	85	23	100	22	80	23	20	22
27	9	1	35	1	80	1	20	1	100	1
28	60	1	50	1	100	1	35	1	75	1

* This participant has encountered problems during their WePWPEP session.

Table D.2 – Participants' weights of the evaluation sub-criteria.

Participant ID	Criterion	Sub-criterion	Weight	No. changes
1	Local impact	Noise impact	100	0
		Shadow flicker effect	20	0
		Impact on property value	59	0
4	Impact on landscape	Site remoteness	100	0
		Cumulative impact	100	0
		Distance to major roads	100	0
		Distance to large settlements	100	0
8	Visual impact	Local inhabitants	52	0
		Road users	12	0
		Recreational environments	100	0
		Built heritage	49	0
		Designated areas	59	0
9	Visual impact	Local inhabitants	20	0
		Road users	100	0
		Recreational environments	0	0
		Built heritage	50	0
		Designated areas	0	0
	Local impact	Noise impact	100	0
		Shadow flicker effect	80	0
		Impact on property value	80	0
10	Local impact	Noise impact	100	0
		Shadow flicker effect	60	0
		Impact on property value	30	0
13	Impact on ecology	Birds	90	0
		Nature conservation designations	100	0
14	Visual impact	Local inhabitants	100	0
		Road users	45	0
		Recreational environments	80	0
		Built heritage	40	0
		Designated areas	80	0
16	Visual impact	Local inhabitants	100	1

		Road users	39	1
		Recreational environments	51	1
		Built heritage	40	1
		Designated areas	84	1
	Impact on landscape	Site remoteness	100	2
		Cumulative impact	40	2
		Distance to major roads	91	2
		Distance to large settlements	90	2
	Site characteristics	Estimated energy output	100	0
		Size of feasible site	24	0
		Agricultural value of the site	66	0
		Size of closest settlement	13	0
20	Visual impact	Local inhabitants	100	0
		Road users	27	0
		Recreational environments	80	0
		Built heritage	49	0
		Designated areas	90	0
	Local impact	Noise impact	38	0
		Shadow flicker effect	32	0
		Impact on property value	100	0
	Impact on landscape	Site remoteness	80	0
		Cumulative impact	100	0
		Distance to major roads	75	0
		Distance to large settlements	75	0
25	Local impact	Noise impact	100	0
		Shadow flicker effect	10	0
		Impact on property value	10	0
26	Site characteristics	Estimated energy output	100	4
		Size of feasible site	20	4
		Agricultural value of the site	10	4
		Size of closest settlement	20	4

Table D.3 – Participants' comments on decision problem structuring.

Participant ID	Webpage	Comment submitted in response to questions in the second tier (MC-SDSS)
1	Feasible sites	It was not clear to me initially how the sites had been already identified according to feasibility. I had not realised that clicking on the writing would give me an explanation of the methodology with which they were defined. With some additional explanation that was fine. Could the box on the upper right with the specification of the layers be expanded so all the writing is visible.
5	Impacts on landscape	The aspects which make up 'impact on landscape' (well, 1, 3 and 4) are more a measure of how many people will see them, or how hidden a turbine is rather than the impact on a particular site. A very attractive secluded place may be seriously visually impacted but few people will see it in day to day living.
8	Feasible sites	I think there should be more off shore, doesn't seem to be any here.
	Visual impacts	I think it needs to be thought out thoroughly which this system seems to be doing well. You can't please everybody so there needs to be criterion for the decision making, such as don't build one in the middle of a small town, or a place where known endangered birds or wildlife live.
	Local impacts	People just don't want to see one out of their window but in the long run it will be worthwhile to the environment so I don't think their opinions can be counted over the other issues.
10	Classification	This is a great page. Not sure you needed the previous pages as well.
16	Feasible sites	Some overlap a little...I have chosen impact on landscape partly because for me it includes the visual and ecological impacts.
17	Site characteristics	I would make the colour invert - so that the lighter colours are less suitable.
20	Feasible sites	How are 'Visual Impact' and 'Impact on landscape' different? It seems this feature has a double weighting, and I would consider it less important.
		Does local impact also need to include potential cost of installation, and job creation? Generally well thought out though.
23	Local impacts	I think it is not that significant in the wind farm development but it is the main reflection.
	Impact on landscape	I think the safety reason is the most important part.

25	Impact on landscape	Improving access roads to potential sites is also a substantial cost. If the appearance of an area has already been compromised by road building then it makes sense to site windfarms alongside them. Avoiding loss of electricity due to long distances over the grid should also be a major factor.

Table D.4 – Participants' contributions to the discussion taking place in the AM.

Participant ID	Contributions added to Argumentative Map		
	Contribution type	**Title**	**Message**
2	neutral	Re: Re: EcoTech wind turbine is beautiful	The approach by road, from Norwich, to Swaffham is made visually attractive by the location of the two wind turbines that can be seen.
3	neutral	Localising It	I think there really needs to be more community involvement. Somehow the organisation of windfarms needs to be something that the local community can be proud of, rather than the national government demanding that windfarms be put in. It basically just needs to be more localised. For example, perhaps the energy from the local windfarm can go directly to the community surrounding it. Perhaps create some friendly competition between communities to see who can make the most energy. Right now windfarms are just too disconnected from the local community. I think this really needs to be changed.
4	suggestion	Re: Localising It	As windfarms affect the local people just as much as they affect the government, if not more due to the visual impacts etc, I feel that the local community is the major stakeholders and should be as involved as possible in the siting of windfarms.
8	question	Wind farms at sea	Why are there not many windfarms at sea? There would be less impact on the ecosystem and wouldn't destroy peoples views or homes.
16	neutral	Re: Wind turbines look great	Yes, they do look good. I agree 'graceful'. But, I think they detract from landscapes that are otherwise beautiful without them. So, okay they add something in the Black Country...put them near Birmingham but not in the beautiful Welsh mountains. I talk about Wales because I know it but the same goes for the rest of the UK. But, it's windiest in the most beautiful places.
23	neutral	Re: We need wind energy	I agreed with it because UK has the large amount of wind resources than other European countries. I think we should make use of it

24	neutral	Wind energy	I am for wind energy. It always has the positive and negative sides when we implement something. I think that wind energy is one of the ways to generate the electricity with having least negative sides. Also, the best thing of wind energy is environmental friendly.
25	neutral	Re: Localising It	It is difficult to argue that local communities need to be handed more control over their windfarms given that central government is subsidising renewables. It is for the national and international good and is because of internationally-agreed climate change obligations e.g. Kyoto. Strong central government leadership is needed, local planning objectives may unnecessarily delay the development of renewable energy projects.
26	question	Re: Wind farms at sea	Do we really know what ecological damage we could be doing by building offshore wind farms? Our understanding of the sea bed ecosystem is limited and off shore wind farm development could be causing a lot of damage.

UNIVERSITY OF LONDON

SENATE HOUSE. MALET STREET, LONDON, WCIE 7HU

REPRODUCTION OF THESES

A thesis which is accepted by the University for the award of a Research Degree is placed in the Library of the College and in the University of London Library. The copyright of the thesis is retained by the author.

As you are about to submit a thesis for a Research Degree, you are required to sign the declaration below. This declaration is separate from any which may be made under arrangements with the College at which you have *pursued* your course (for internal candidates only). The declaration will be destroyed if your thesis is not approved by the examiners, being either rejected or referred for revision.

Academic Registrar

To be completed by the candidate

NAME IN FULL (please type surname in BLOCK CAPITALS)

01/ANA CRISTINA ROCHA-SIMAO

THESIS TITLE A learning-enhancing, web-based public participation system for spatial planning: an application to the wind farm siting problem.

DEGREE FOR WHICH THESIS IS PRESENTED Doctor of Philosophy (Ph.D.)

DATE OF AWARD OF DEGREE *(To be completed by the University)*: 30 JUN 2009

DECLARATION

1. I authorise that the thesis presented by me in *[2007] for examination for the MPhil/PhD Degree of the University of London shall, if a degree is awarded, be deposited in the library of the appropriate College and in the University of London Library and that, subject to the conditions set out below, my thesis be made available for public reference, inter-library loan and copying.

2. I authorise the College or University authorities as appropriate to supply a copy of the abstract of my thesis for inclusion in any published list of theses offered for higher degrees in British universities or in any supplement thereto, or for consultation in any central file of abstracts of such theses.

3. I authorise the College and the University of London Libraries, or their designated agents, to make a microform or digital copy of my thesis for the purposes of inter-library loan and the supply of copies.

4. I understand that before my thesis is made available for public reference, inter-library loan and copying, the following statement will have been included at the beginning of my thesis: The copyright of this thesis rests with the author and no quotation from it or information derived from it may be published without the prior written consent of the author.

5. I authorise the College and/or the University of London to make a microform or digital copy of my thesis in due course as the archival copy for permanent retention in substitution for the original copy.

6. I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

7. I understand that in the event of my thesis being not approved by the examiners, this declaration would become void.

***Please state year by hand, using a pen.**

DATE 25 May 2007 SIGNATURE

Note: The University's Ordinances make provision for restriction of access to an MPhil/PhD thesis and/or the abstract but only in certain specified circumstances and for a maxiumum period of two years. If you wish to apply for such restriction, please enquire at your College about the conditions and procedures. External Students should enquire at the Research Degree Examinations Office, Room 261, Senate House.

THIS DECLARATION MUST BE COMPLETED AND RETURNED WITH THE EXAMINATION ENTRY FORM